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ABSTRACT

This instructor's guide accompanies the self-paced student training modules on welding, three of which are available separately as CE 032 889-891. Introductory materials include a description of the components of the pre-apprenticeship project, a discussion of the teacher's role in conducting the course, and scope and contents of the four phases of training. The guide contains 12 units organized according to this format: title; instructional outcomes; introduction; and presentation, including a teaching outline of the unit and teaching methods and aids referenced to student modules. Job sheets and drawings are provided as needed. Topics covered in the units include the following: introduction to the welding trade, diagnostic testing for welders, survival skills for welding, trade mathematics, physical requirements for welding, safety, first aid, blueprint reading, equipment for welding, welding processes, and a welding project. An appendix contains an occupational analysis (task inventory) of the welding trade. (KC)

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INDIVIDUALIZED LEARNING SYSTEMS

PRE-APPRENTICESHIP

PHASE 1 TRAINING
Instructor's Guide

Welding

Diagnostic Tests
Survival Skills
Math
Tools
Materials
Project

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CE032888

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INTRODUCTION TO PRE-APPRENTICESHIP

DESCRIPTION OF APPRENTICESHIP

The Federal Bureau of Apprenticeship identifies an apprenticeable occupation as a skilled occupation that requires a minimum of one year of 2000 hours on-the-job training. This on-the-job training and related educational training is the apprenticeable period.

VIEWPOINTS ABOUT PRE-APPRENTICESHIP

Pre-apprenticeship is viewed in many different ways by craftpersons, apprenticeship committees, educators and the general public.

Concerns about pre-apprenticeship include the belief that the pre-apprenticeship training will flood the market with applicants for apprenticeship or that these trainees will go to work in the occupation as partly trained workers or that pre-apprenticeship would be considered a guarantee of entry into apprenticeship. These conflicting viewpoints create problems for persons interested in apprenticeship training and make it difficult to operate pre-apprenticeship training programs.

NEED FOR PRE-APPRENTICESHIP

Pre-apprenticeship provides three benefits:

1. Provides a screening device to determine motivation, interest, manipulative aptitude and ability of persons to learn the skills of the occupation.
2. Provides the individual with survival skills for handling personal problems and interpersonal relations on the job that may include abuse and sexual harrassment.
3. Provides entry level skills to help make the apprentice productive from the first day on the job. The higher entry level skills of the apprentice provides an incentive for the employer to hire apprentices.

PRE-APPRENTICESHIP HELPS PEOPLE

To select a skilled occupation.
To identify the educational requirements of an occupation.
To experience the hands-on skills of an occupation.
To develop good work habits.

* Good job attendance
* Punctuality
* Dependability
* Time management

To develop good attitudes.

* Concern for the job
* Initiative
* Interest
* Healthy, cooperative working relations with fellow employees.

TRAINING LEVELS FOR PRE-APPRENTICESHIP

Pre-apprenticeship training can be separated into three phases or stages of training. These are:

PHASE 1

Provides the trainee with an opportunity to explore several occupations. This orientation to the electrical trade includes training in trade terminology, blueprint reading, tool usage, first aid and safety practices. This familiarization training includes hands-on experience in some of the basic skill areas together with information about the advantages and requirements of electrical work. The choice of an occupation to train for in Phase 2 of pre-apprenticeship will be based on these experiences. If the trainee decides not to pursue this occupation any further, the training received to this point will be useful in every day life.

Phase 1 includes diagnostic tests to determine if reading or mathematical deficiencies exist that would handicap a person in the electrical trade. Remedial work will be provided to correct these deficiencies.

Success on the job is directly related to job attitudes, work habits, and the individual survival and coping skills. Training will begin on helping each individual attain full potential in these personal skills.

Interpersonal skills will be developed which include:

* Communication skills
  - paraphrasing, perception checks, non-verbal communication
  - communicating with superiors
* Personal effectiveness
  - problem solving, family relationships, sexual harrassment and pestering on the job.
* Interview techniques
  - apprenticeship committee interview procedure

PHASE 2

This training begins the serious preparation for an occupation. The training related to job attitudes, work habits and individual survival and coping skills will be continued from Phase 1 with more emphasis on the relationship to the job.

Manipulative skills will be developed by the completion of a series of projects involving basic trade skills which have a carryover benefit to persons outside of the occupation. At least 3/4 of the training will consist of hands-on experiences. This instruction should be conducted by a skilled craftsperson from the trade or occupation who has the necessary teaching skills.

The joint apprenticeship committee for the occupation will be invited to observe the progress of trainees during Phase 2 and to evaluate the potential for trainees for entry into apprenticeship. The participation of the appropriate joint apprenticeship committee is essential to the success of a pre-apprenticeship program. This community involvement insures that the training is relevant to the occupation and meets industry training standards.

At the completion of Phase 2 the trainee will have enough experience with the occupation to decide whether to continue with the training into Phase 3. The joint apprenticeship committee will have knowledge of the quality of the training program and will be in a position to judge the qualifications of the students for entry into the apprenticeship training program.

PHASE 3

Training is concentrated on improvement of manipulative skills so that the trainee will be a productive employee the first day on the job. This training can be either industry conducted specialized training, secondary school vocational programs or community college preparatory courses specifically related to the occupation. Trainees can also participate in co-op work experience involving hands-on training at the secondary or community college level. Hands-on training is considered essential for an effective pretraining program.

The Phase 3 training period provides the trainee with an opportunity to search for an employer willing to take an apprentice. Frequently the employer providing co-op work experience training will hire the trainee as a regular employee.

It is possible that some employers will hire the trainee without further training. Some of these employers train specifically for their own needs. In the process, job descriptions have become highly diluted. Instead of producing journeymen possessing a wide range of skills, companies have settled for specialists trained to perform the specific tasks needed in certain narrow operations. While this may be adequate to meet the special needs of an industry, it certainly will not meet the training and manpower needs of the nation in the future.

Apprenticeship provides a broad base of training by giving the apprentice a wide range of skills which insures continuous employment. Workers least vulnerable to unemployment are those with the highest and broadest skills and best training. The trainee should make every effort to enter an apprenticeship training program designed to provide training in all skills required

in the trade or go to work for an employer who will provide broad based training.

Each trainee will choose a joint apprenticeship committee meeting to attend during Phase 3 training. This will provide an opportunity for the trainee to become acquainted with members of the joint apprenticeship committee and to see how the committee functions.

PHASE 4 EMPLOYMENT AS AN APPRENTICE

Trainee enters apprenticeship training on a direct referral basis under agreement with the appropriate joint apprentice committee which permits persons trained in programs financed with federal funds to enter apprenticeship on direct referral. Direct referral eliminates several of the procedures in the selection process and makes entry into apprenticeship less cumbersome.

Not all joint apprenticeship committees use the direct referral system. This is the reason why sponsors of pre-apprenticeship training should directly involve joint apprenticeship committees in the operation of their programs. This provides committees with an opportunity to evaluate the effectiveness of pre-apprenticeship.

The federal Job Corps Programs enjoy direct referral placement in apprenticeship for their graduates. The Job Corps operates an ideal pre-apprenticeship program. Proposed sponsors of pre-apprenticeship training are advised to visit the nearest Job Corps Center to see how the programs operate.

The Job Corps Centers in Oregon are located at:

Angel Job Corps
Star Route North
Yachats, OR 97498
547-3137

Timber Lake Job Corps
Star Route Box 109
Estacada, OR 97023
834-2291

Wolf Creek Conservation Center
Little River Route
Glide, OR 97443
496-3507

Tongue Point Job Corps
Astoria, OR 97103
325-2131

Job Corps Centers in Oregon Offer Training in these apprenticeable occupations:

Carpentry	Plastering	Automotive
Cement Mason		Painting
Brick Laying	Tile Setting	

RECOMMENDED PROCEDURE FOR CONDUCTING PRE-APPRENTICESHIP TRAINING

ADMINISTRATION

Pre-apprenticeship training can be conducted by various sponsors. These include: secondary schools, community colleges, unions, employer associations, labor/management training trusts and private groups such as O.I.Cs.

ADVISORY COMMITTEES

Use of broad-based community advisory committees is mandatory for pre-apprenticeship programs conducted by secondary schools and community colleges. Pre-apprenticeship needs the support and recognition of the community in order to be successful.

The advisory committee should have representatives from these groups:

School administration
- -high school principal
- -board members
- -vocational director
- -co-op work experience
- -T & I instructors

Community
- -school graduate in trade
- -member of joint apprenticeship committee
- -employer member of trade
- -employee member of trade
- -union business agent
- -industry training coordinator
- -representative of financial community
- -representative of press

Government personnel
- -ESD regional vocational coordinator
- -Oregon Division of Apprenticeship field representative
- -Federal Bureau of Apprenticeship representative
- -State Dept. of Education specialist

FINANCING

Vocational training programs generally cost more than academic programs because the student/teacher ratio is smaller, consumable supplies are required, and expensive equipment is needed. Resources to finance pre-apprenticeship training are available from a number of sources. These include:

Vocational rehabilitation	-tuition fees
Federal funds for immigrants	-Asian -Cuban -Spanish American
Special grants	-U.S. Dept. of Labor U.S. Dept. of Education CETA Industry State Dept. of Education Economic Development Administration
Secondary school funding	-basic school grant from federal funds
Community college funding	-basic state funding

INSTRUCTIONAL DELIVERY SYSTEMS

The type of sponsor for pre-apprenticeship training will determine the time-block used for the program. If training is started at the 9th grade level, a two-hour training period will generally be used. A half-day training period should be used for an accelerated program at the secondary level covering two years. Community college programs can be either half-day or full-day programs. Private sponsors generally will operate on a full-day basis.

Instructors for the trade specific training should be qualified craft workers. These may be employed on a part-time basis, or full-time, serving several programs. The necessity for skilled workers to teach the trade specific items of the program

MISCELLANEOUS CONSIDERATIONS

Legislation, community support and political considerations will all have an effect on pre-apprenticeship training. Activities related to these concerns include:

Workshops and technical assistance	-State Dept. of Education
Publicity notices	-public service -newspaper -radio -translation to Asian/Spanish American
Civil rights	-effect of civil rights compliance
Transfer of learning	-benefits of vocational training to other occupational endeavors

8.0 Blueprint Reading

- 8.1 Scaling and Dimensioning
- 8.2 Sketching
- 8.3 Drawing Types and Views

9.0 Equipment

- 9.1 Equipment

10.0 Welding Processes

- 10.1 Weld Joints
- 10.2 Puddle Without Rod
- 10.3 Puddle With Rod
- 10.4 Forehand and Backhand
- 10.5 Weld Corner Weld Without Rod
- 10.6 Butt Weld Flat Position
- 10.7 Flange Weld
- 10.8 Lap Joint Fillet Weld
- 10.9 "T" Joint
- 10.10 Electric Arc Welding
- 10.11 Selecting Current
- 10.12 Selecting Electrode
- 10.13 Striking an Arc
- 10.14 Running Bead Using Arc Welder
- 10.15 Flat Position Arc Welding
- 10.16 Flat Butt Vee Weld
- 10.17 Common Causes of Welding Problems
- 10.18 Bead with Filler Rod in Vertical Position
- 10.19 Bead with Filler Rod in Horizontal Position
- 10.20 Bead with Filler Rod in Overhead Position
- 10.21 Open Butt Weld in Vertical Position
- 10.22 Open Butt Joint in Overhead Position
- 10.23 Open Butt Joint in Horizontal Position
- 10.24 Fillet Weld in Vertical Position
- 10.25 Fillet Weld in Horizontal Position
- 10.26 Lap Joint in Vertical Position
- 10.27 Lap Joint Fillet Weld in Horizontal Position
- 10.28 Fillet Weld in Overhead Position

11.0 Project

II. WORD TO THE INSTRUCTOR

This course was designed to be a trade-related, self-screening, job exploration package, providing the student with basic trade theory, basic trade manipulative practice, projects and on-job-site visitations.

Further, it is to be implemented by instructors who are skilled in each of the general topics described in the course outline and expanded on in the instructor's guide.

The curriculum is comprised of two parts: 1) the instructor's guide, and 2) supporting modules and references which are specified in the instructor's guide. The instructor should seek other supporting resources where available or necessary.

The instructor should bear in mind that there are two broad objectives written into the design of this course: 1) that the student will receive instruction in the preapprenticeship mode of the trade (which is designed to enable him or her to gain enough exposure to the trade to (a) aid in making a career decision, and (b) facilitate entry into the trade), and 2) that the student will retain some carryover skills which he or she can use in life, even should the student decide not to enter the trade.

Essentially, this guide is patterned after a program begun in Oregon in 1979-80. The participants in the program are wholly CETA-sponsored, many with motivational or physical impairments. The program concentrates on providing motivational support and/or physical therapy. A typical program, broken down into its major components, would be:

40% hands-on, manipulative work
30% motivational support work
10% job visitation
5% physical development or therapy
15% class lecture, discussion, etc.

Not all institutions will have the resources, nor will all programs' students have the need, for such a breakdown. The instructor should identify the needs of the students and utilize the guide in the manner best suited to meet them.

III. RECOMMENDATIONS

Hands-on work is probably the best learning experience for students in trade work. It is essential if the two broad objectives listed above are to be met. Therefore, implied in the topics covering tools, materials and tasks or work processes is the notion (emphasized in the Instructional Outcome for these topics) that the student will practice using the tools and materials described therein.

In lieu of describing in the Teaching Methods and Aids section of the guide those tasks which will be performed with the described tools and materials, the writers leave it to the imagination and material resources of the instructor. Practice is the method by which skill is developed.

1.0 Introduction to the Welding Trade

INSTRUCTIONAL OUTCOMES: The student will be able to identify and briefly explain the history, the five major welding processes, employment opportunities and working conditions, as well as working people's benefits and trade terminology.

INTRODUCTION: In order to become an effective worker or make an effective, realistic career decision, an individual must be exposed to various aspects of the trade.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
1.1 History A. Welding is considered either an ancient art or a modern skill. 1. Gold and brass were welded in 2000 B.C. 2. Iron was welded at least by 1000 B.C. B. Industrial revolution of 19th century was largely accomplished without the use of welding. C. Industrial welding is a 20th century advancement.	ILS Introduction to Welding Explain and Discuss

1.2 Processes of Welding

A. There are many processes.
   1. All welding involves fusing of two or more pieces of metal.

B. Gas welding started in the 1850s with hydrogen and oxygen.

C. Inexpensive acetylene was produced in the 1890s and oxy-acetylene welding began.
   1. Gas cutting involved use of intensely hot gas flame to melt and fuse two metals, with or without additional metal for a filler.

D. Arc welding was discovered by two Russian scientists in 1885.
   1. The first coated electrodes appeared in 1910.
      a. major advances in arc welding were achieved in 1940s when it became the major steel welding process in industry.
      b. process involves striking an electric arc between an electrode and the metal to be fused, and depositing melted electrode at the point where fusion is taking place

E. Electric resistance welding.
   1. High current is passed between two pieces of metal in contact.
      a. electrical resistance generates high heat and fusion takes place where electrodes create pressure.

(1) spot welding.
(2) a seam can be welded with a series of overlapping spot welds.

2. Resistance welding equipment is generally heavy and designed for a single application.
3. Electric resistance welding is a major production method in sheet metal fabrication.

F. TIG welding (GTAW)--gas tungsten arc welding
1. Was developed during W.W. II in answer to a need for welding magnesium metals.
2. An arc between a tungsten electrode and the work is shielded by a stream of inert gas (argon, helium, or a mixture of the two).
   a. protects both the electrode and the metal from the air which would cause impurities and other harmful effects in the weld.
3. Expensive process, but is widely used for magnesium, aluminum, titanium, stainless steel and other "exotic" metals.

G. MIG welding (GMAW)--Gas metal arc welding.
1. Grew out of TIG welding.
2. Electrode is continuously fed wire which melts into the work with the heat of the arc.
3. Work is protected by a shielding gas.

4. Being applied in a greater variety of high production applications everyday. H. The five listed welding processes are major ones used in industry. 1. The process used is determined by: a. the kinds of metal to be joined. b. the costs involved. c. the kind of products to be made. d. the production techniques. I. Some other welding processes in use today are: 1. Forge welding. 2. Submerged arc welding. 3. Electroslag welding. 4. Flux-covered arc welding. 5. Plasma arc welding. 6. Electron beam welding. 7. Laser beam welding.	
1.3 Employment Opportunities A. Welding has an exciting future. B. As raw materials become more expensive and harder to find, rework and repair of old equipment and products becomes more important. 1. Welding is almost always a part of that process. C. The field of welding is expanding and will continue to do so.	Jobsite Visitation Invite Job Specialist

1.4 Working conditions A. Welding is performed almost anywhere and under almost any conditions. 1. May be done in sub-arctic or tropical climates, in mid-air on a structure, or underwater. 2. May be done in mud under a tractor, in a crowded ship comparment, or in a very clean room in a modern industrial complex. B. Where one works depends on his or her choice, education, training and experience	Jobsite Visitation
1.5 Common Worker Benefits A. Unemployment Insurance 1. Purpose. a. transition from job to job. b. ease strain of layoffs. 2. Source of benefits. a. payroll tax on wages. 3. Eligibility. a. depends on base year earnings. b. depends on reasons for leaving work. 4. Level of benefits. a. level of base year earnings. 5. Claims process. a. report to Employment Division office. b. provide required information. (1) employer's name and address. (2) your social security number. (3) wage earning records. (4) current address.	Explain and Discuss ILS, Common Worker Benefits Invite Field Rep from Workmen's Compensation Board BOL Wage and Hour Employment Division

6. Appeals/hearing process.
   a. initiated by worker.
   b. in writing.
   c. within time limits.

B. Wage and Hour Commission
   1. Purpose.
      a. to investigate and attempt equitable settlement of wage claims.
   2. Areas of claim review.
      a. pay periods.
      b. pay days.
      c. final pay days.
      d. wage payments in cases of dispute.
      e. methods of compensation and overtime.
      f. minimum wage laws.
      g. limitation of hours in certain industries.
      h. restrictions on employment of minors.
   3. Jurisdiction.
      a. Federal vs. State.
   4. Claim Process.
      a. contact wage and hour commission.
      b. provide required information on appropriate form.
         (1) dates of employment.
         (2) rate of pay.
         (3) reason for non-payment.
         (4) estimate of disputed amount.
      c. wage claim conference.
      d. collection process.
      e. protection against retaliation for filing a claim.

5. Time limits for filing.
    a. regular pay.
    b. overtime pay.

C. Workers Compensation
    1. Purpose
        a. provide medical care payment for on-the-job accidents.
        b. provide time loss payments.
        c. provide payments for permanent disability.
        d. provide death benefits.
    2. Source of benefits.
        a. employer premiums for insurance.
        b. employee contributions.
    3. Level of benefits.
        a. complete for medical costs.
        b. varies according to level of final disability.
    4. Eligibility.
        a. any job-related accident or condition causing the worker to leave work and seek medical treatment.
    5. Claim process.
        a. report accident to employer.
        b. fill out claim form.
            (1) know your employer's legal name.
            (2) know your employer's insurance carrier.
        c. see your doctor for treatment.
    6. Final determination.
        a. doctor's statement of stabilized condition.
        b. board's findings of disability and payment.

7. Reopening claim for aggravation of injury without a new injury.
   a. contact employer's insurance company if occurs within the first five years.
   b. contact worker's compensation board after five years.

1.6 Trade Terminology

A. Common Trade Terms.

1. Pliers--hand-held gripping tool.
2. Strikers--spark emitting tool used to light torch.
3. Chipping hammer--small pick like hammer used to clean up welds.
4. Wire brush--metal bristled hand tool used to clean up metal surface in welding.
5. Ferrous--containing iron; as steel is a ferrous metal.
6. Non-ferrous--substances without iron; as copper, brass.
7. Regulator--device used to meter and monitor the flow of gases.
8. Torch--device used to mix oxygen and acetylene in the correct proportion and control of flame during welding.
9. Tip--final opening through which flame passes. Diameter of opening governs tip size.
10. Electrode--thin metal wire coated with a special substance and used as a filler material to join metal being welded.

11. Acetylene--gas formed by the mixture of calcium carbide and water.
12. Oxygen--combustable gas derived from the air by a chemical process.
13. Rod--metal formed into rod shape used for welding.
14. Bead--continuous length of weld.
15. Bevel--slope/angle applied to edge of metal in joint preparation.
16. Joint--site where metals are joined by weld.
17. Fillet weld--weld with near triangular crossection joining two surfaces at right angles to each other.
18. Lap joint--where metal pieces overlap each other.
19. Butt weld--metal pieces meet on edge for weld.
20. T-joint--where metal pieces intersect at right angles.
21. MIG welding--gas tungsten arc welding using where tungsten electrode provides arc but not consumed.

2.0 Diagnostic Testing/Welder

INSTRUCTIONAL OUTCOMES: The Student will complete a Specific Aptitude Test Battery (SATB), administered by a qualified examiner and will have the results explained by a qualified examiner.

INTRODUCTION: The General Aptitude Test Battery is a standardized test that has become recognized as the best validated multiple test battery in existance for use in vocational guidance. The tests are used by apprenticeship committees to assist in the screening process for appropriate candidates when apprenticeship openings occur, and to provide individuals with an indication of the probability of their being successful in a particular trade.

Many apprenticeship programs require applicants to have certain aptitudes as demonstrated by passing appropriate tests. For example, the applicant may be required to pass Specific Aptitude Test Battery (SATB) administered by the State Job Service. SATBs test two or more of the following nine general aptitudes: general learning ability (cognitive functioning), verbal aptitude, numerical aptitude, spatial aptitude, form perception (ability to perceive small detail), clerical perception (ability to distinguish pertinent detail), motor coordination, finger dexterity and manual dexterity.

Each battery tests different combinations of these nine general aptitudes because each occupation requires different specific abilities. The following SATB tests and cutting scores are required by the apprenticeship committee for the trade. The student should be aware of the trade requirements and determine how he or she feels about his or her abilities in the tested aptitudes in order to make a career decision.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
2.1 SATB A. Complete exam described below KEY: Trade Occupation Code # for the occupation SATB for the trade = Recommended cutting	

score for the trade
Location of the SATB within the GATB

WELDER (COMBINATION) S#126
Spatial Aptitude = 85
Three Dimensional; Book I, Part 3

Finger Dexterity = 85
#11 Assembly, #12 Disassemble, Board

Manual Dexterity = 80
#9 Place, #10 Turn, Board

	Cutting Scores		
	Adult	Grade 10	Grade 9
Spatial Aptitude	80	80	77
Finger Dexterity	80	75	72
Manual Dexterity	85	79	76

B. Discuss Results:

3.0 Survival Skills/Welding

INSTRUCTIONAL OUTCOMES: The student will learn and practice fundamental concepts in: a) dealing with expectations, b) communication skills, c) giving and receiving feedback, d) dealing with interpersonal conflict, e) group problem-solving, goal-setting and decision-making, f) outside influences and responsibilities, g) identifying individual strengths, h) appropriate work habits and attitudes, and, i) phases of job search and worklife.

INTRODUCTION: Training and proficiency in human relations skills are essential for successful adaptation to worklife. All too often in job preparation programs, these basic survival skills are neglected or put aside in favor of training in the technical aspects of work.

This topic describes the many skills necessary to become a stable, productive and satisfied worker.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
3.1 Expectations A. Predicting the future 1. Self-fulfilling prophecies a. setting yourself up for failure b. thinking positively	ILS Survival Skills-Expectations PREPARATION Be familiar with the material beforehand, and think up some relevant examples AVAILABILITY Be available to students. Go around those students reading the material. Be prepared to answer and ask questions that increase students' understanding.

E. Self-Assessment--looking at common personal expectations F. Post Assessment	IDENTIFY PROBLEM AREAS Go through questions to see where students are putting themselves down. Give encouragement. Ask what they want to change. EXPLAIN Read through examples, answer questions. FLEXIBILITY Allow students to demonstrate their understanding in less than suggested number of situations.
3.2 Communication Skills A. Good communication 1. two-way process 2. importance 3. innate abilities 4. showing mutual respect B. Active listening. 1. Centering attention on the other person. a. being seen to be listening b. finding out what is important to the other person c. following the other person's lead d. listening to feeling 2. Checking that you have understood what the other person is communicating. a. checking feeling	ILS Survival Skills-Communication Skills. PREPARATION Be familiar with the material. BEING A ROLE MODEL Demonstrate active listening. Ensure that students voice problems and doubts. Allow frequent opportunity for students to give responses to on-going work. Be ready to demonstrate bad examples of listening, to group or individuals, and contrast with good examples.

b. checking content
c. when it is inappropriate

C. Being listened to.
1. Your rights as an individual
2. When to keep quiet
3. Avoiding being aggressive
4. A three-step approach
a. showing you understand
b. taking responsibility for your own feelings
c. suggesting alternatives

D. Overall importance of respect for individuals
1. Communication between equals

E. Self-Assessment
1. How individuals communicate with others

F. Practicing the skills in triads
1. Active listener of personal experience
2. Role play being listened to

ASSERTIVENESS

Draw examples from books on being assertive. Think up appropriate examples in work context. Discuss aggressive responses with individuals. Describe alternative approaches. Discuss possible exceptions--where aggression might be appropriate.

INSTRUCTOR/STUDENT RELATIONS

Assess relations in class in terms of respect for, and equality of, individuals. Ask students for comments.

IDENTIFY PROBLEM AREAS

Give help and encouragement. Find out from students what skills they want to practice.

TRIADS

Form triads (trios) as students finish Self Assessment.

FEEDBACK

Listen to one example of active listening in each triad. Give suggestions for improvement. Be open to alternative situations for the role play. Ensure students are willing to practice being sensitive to possible reluctance and shyness. Be prepared to role play yourself.

3.3 Giving and receiving feedback

A. Importance of being able to give praise and criticism (introduction).

B. Importance of group support and teamwork
   1. Being a team member
   2. Building a team
      a. knowing where you are
      b. pulling your weight
      c. responsibilities for others
      d. group aims and goals
   3. Poor working environments
      a. indirect communication
      b. not knowing where you stand

C. Reading attitudes
   1. Hired or fired?
   2. How do you come across to other people?
   3. Interpreting other people's behavior

D. Giving and receiving positive opinions
   1. Importance of praise
   2. Taking compliments
   3. Giving praise

E. Getting and giving criticism
   1. Its importance
   2. Being criticized
   3. Avoiding being threatened
   4. Between equals

F. Self Assessment-Feelings and Preferences

ILS Survival Skills-Giving and Receiving Feedback

PREPARATION

Be familiar with the material and prepared to participate actively and equally.

FACILITATION

Facilitate continuously the building of group support. Give extra support to students who have difficulties participating fully. Enlist help of more confident and verbal to share the responsibility. Give support, but principally be a neutral chairperson or facilitator. Encourage group members to observe each others' non-verbal behavior between class times.

POSITIVE REINFORCEMENT

Give frequent verbal praise to individuals who are working well and to the group as it becomes more supportive

MONITORING

Walk around and ask permission to join in some partner discussions. Encourage greater depth. Avoid any judgments. Use paraphrase

G. Assignments 1. Telling individuals what you like	and feeling as checking skills. A DEVELOPING PROCESS Introduce when group is ready. First three assignments could be practiced even before module has been read. Explain, in turn each assignment to whole group. Deal with worries, doubts or questions before you begin.
2. Reading attitudes within the group. 3. Opening self-sharing important experiences	Use all your facilitating skills. Especially be sensitive to members' non-verbal responses. Follow up, after the class, on any individual who is upset. At all times encourage positive support within the group. Be prepared to intervene if criticism becomes too negative.
4. Receiving direct positive feedback 5. Receiving direct positive and negative feedback	
H. Post Assessment	Organize small groups or lead discussion of whole group. Use small groups to extend each individual's range of interactions.
3.4 Dealing with interpersonal conflict	ILS Survival Skills-Dealing with Interpersonal Conflict
A. Consequences of poor interpersonal relations	PREPARATION Be familiar with the material and ready to supply further relevant examples from the

B. Recognizing conflict in a work context
   1. Open arguments
   2. Possible causes
   3. Consequences

C. Them and Us atmosphere
   1. The conditions you deserve
   2. Whose responsibility?

D. Unproductive ways of solving conflict
   1. Finding someone to blame

E. Productive ways of solving conflict
   1. Taking responsibility for doing something about it
      a. when people feel threatened by you
      b. when you feel threatened

F. Remaining passive.
   1. Poor working conditions
   2. Physiological and psychological problems
   3. Irrational fears
      a. fear of not being liked
      b. fear of hurting others

G. Action model for solving interpersonal conflicts
   1. Choosing the best time
   2. Taking responsibility for your feelings

world of work.

BE AVAILABLE

Encourage students to comment and question points as they arise. Ask them to come up with their own examples, either confirming or disconfirming the information.

RESPONSIBILITY

Throughout Survival Skills, individual responsibility is repeatedly stressed. Periodically, reassess your own role. Avoid being pushed into the "expert" stance. Try to be an impartial facilitator, encouraging student's learning without passing judgments. Ensure students take responsibility for what they want to achieve.

3. The four-step language formula. a. tell the other person that what he or she is doing is upsetting you b. speak your feelings c. describe how his or her behavior is affecting you d. suggest an alternative H. Negotiating 1. Give and take 2. Compromise I. Discrimination and prejudice 1. Different types 2. Dealing with it	
J. Self Assessment	IDENTIFY IMPORTANT GROUP ISSUES Deal in a neutral manner with examples of discrimination. Ask individuals for personal experience of racial and sexual prejudice and discrimination. Facilitate discussion on Equal Opportunity and Affirmative Actions. Invite solutions to problems from group members. NEW ISSUES Be aware of any controversial issues that arise during the Self Assessment. Introduce them to the group for general discussion.
K. Assignments 1. Sharing in small groups.	ORGANIZE GROUPS Form groups as students finish writing. Limit talk to five minutes on each topic. Maintain some urgency by announcing the five minute intervals.
L. Post Assessment 1. The formula	COLLECT WORK Read and make encouraging

3. The four-step language formula. a. tell the other person that what he or she is doing is upsetting you b. speak your feelings c. describe how his or her behavior is affecting you d. suggest an alternative H. Negotiating 1. Give and take 2. Compromise I. Discrimination and prejudice 1. Different types 2. Dealing with it	IDENTIFY IMPORTANT GROUP ISSUES Deal in a neutral manner with examples of discrimination. Ask individuals for personal experience of racial and sexual prejudice and discrimination. Facilitate discussion on Equal Opportunity and Affirmative Actions. Invite solutions to problems from group members.
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L. Post Assessment 1. The formula	COLLECT WORK Read and make encouraging

2. Personal examples	written comments. Arrange contract for completion of work with any students who produce low standard work.
3.5 Group Problem Solving, Goal Setting and Decision-making A. 10-step model 1. Define the problem 2. Look at the known facts a. what is happening b. who is involved c. when does the problem occur d. where does it occur e. why has it become a problem 3. Agree on your goals 4. Pool ideas for achieving your main goal without evaluating them 5. Look more closely at some of the more interesting and unusual ideas 6. Include any other ideas that you think might be helpful 7. Agree on some guidelines for achieving your goal a. be specific about minimum behavior required 8. Decide on a plan to implement your proposed solutions 9. Assess the likelihood of success 10. Evaluate the success of your decisions after they have been implemented. B. Self Assessment	ILS Survival Skills-Group Problem Solving, Goal Setting and Decision-Making PREPARATION AND MATERIALS Know the 10-step model without having to refer to it on the page. Work through the process beforehand. Have photocopies of the model. Have ready one large newsprint pad and one marker for every five students. Choose about six examples of unusual tools or materials that students are unlikely to have seen. Have them ready, but hidden. Get advice from specialists beforehand. AVAILABILITY Go around students in class while they are reading material. Help them understand the 10 steps. CHECK LACK OF UNDERSTANDING Look over individuals' answers. Give help for misunderstandings.

D. Post Assessment	PREPARE HANDOUT Have copies of 10-step model. Make sure students check what they have written and correct it. PERSONAL EVALUATIONS Invite students to read out or tell others what they wrote under 2 in the Post Assessment.
3.6 Wider influences and responsibilities A. Relations with people in authority 1. Formal workplace a. job titles b. hierarchy 2. Informal workplace a. unwritten rules and unstated expectations 3. Showing respect and being relaxed B. Relations with family and friends 1. Changes in responsibilities 2. Affects of changes on old relationships a. being prepared b. communicating problems 3. Planning quality time a. keeping work problems at work b. maintaining relationships	ILS Survival Skills-Wider Influences and Responsibilities PREPARATION Be familiar with the module and gather useful newspaper cuttings, brochures and leaflets that illustrate the range of possible influences on somebody settling down to work. BE A READY RESOURCE Give examples informally to students from personal experience to back up information. DRAW ON STUDENTS' EXPERIENCE Encourage individuals to think of relevant illustrations from their own experience in a work setting.

4. Keeping up leisure activities
5. Home problems at work
   a. leaving problems at home
   b. serious problems

C. Other influences
1. apprenticeship
2. union
3. social organizations
4. other workers
5. state and federal agencies

D. Self Assessment

E. Assignment

F. Post Assessment

SUPERVISION

Ask students to show their answers to the Self Assessment. Since it is a test of comprehension, follow up on any difficulties revealed.

CHOOSING PARTNERS

Encourage students to work with someone different each time. After majority of students have completed assignments, hold a report-back session with whole group. Ask students to summarize and draw conclusions from reports given.

DEMONSTRATE

Show what is required by illustrating it on a chalkboard.

3.7 Identifying and developing individual strengths A. Evaluating yourself and others 1. Expectations 2. Personal theories a. predicting b. controlling B. Identifying personal values 1. Significant role models 2. Eliciting personal constructs 3. Bi-polar nature of constructs	ILS Survival Skills-Identifying and Developing Individual Strengths PREPARATION Work through module beforehand. Acquaint yourself with any areas that might cause difficulties in understanding. Make extra copies of exercise sheets. Refer to ILS Expectations. AVAILABILITY Be at hand throughout this module. For students to discover significant things about themselves, instructions must be followed closely. Ensure that students have had a personal relationship with each of people listed in right column. Ask them to put names they used to address these people. Check students' understanding of procedure. If necessary, go through method with whole group. Ensure that the description is of importance to each student and not superficial, such as hair color, etc. Stress that there is no correct answer; it is important for each person to write what seems opposite to him or her personally regardless of what anyone else might say.

4. Identifying important personal values	ARRANGE PARTNERS Go around and offer interpretations if requested or encourage students to draw conclusions. Ask what they recognize and what is new.
5. Evaluating yourself. a. as you feel you are b. as you would like to be c. looking at the amount of congruity	DISCUSS WITH INDIVIDUALS OR SMALL GROUPS Be tentative about what is identified. The conclusions can only be significant if the individual finds them significant. Use words and phrases such as..."it seems...," "you may..." "I would guess...." "it might indicate.." Use grid to prompt questions rather than answers.
6. Evaluating significant others a. comparing ratings	IN PARTNERS Suggest each student in turn tries to describe what people the other one might like and what people he or she might not like, based on the constructs on paper. Ensure that students follow instructions closely. Encourage them to search for all influences. If they have difficulty, suggest situations where students make choices, e.g. career, friends, classes, out-of-school activities.
C. Influences on personal decisions 1. How much are you in control of your own life? 2. Positive and negative influences. a. other people b. aspects of self c. organizations	

3.8 Worksite Visits A. Building realistic expectations 1. Questioning job descriptions 2. The human side of the job 3. On-the-job visits 4. Talking with people in the trade B. Group visits 1. Exposure to different working environments 2. Practice in observation 3. Asking questions C. Individual visits 1. After working hours 2. Interviewing the worker 3. Arranging the visit D. Self Assessment-Comprehension E. Assignment 1. Looking at Help Wanted ads	ILS Survival Skills-Finding a Job Worksite Visits PREPARATION Arrange with any company that allows it a group visit during working hours. Have sufficient copies for use by whole class of Help Wanted ads from local newspapers. Become an informed source of possible contacts for student interviews with journeymen and apprentices. CHECK UNDERSTANDING Ensure students comprehend all of the material before making any contacts or visits. HELP WITH ASSIGNMENTS Supply Help Wanted sections--one to each student. Suggest they read through and circle in ink interesting ads. Stress importance that each works on his or her own; it is practice in looking for jobs. Collect what students write and report back

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	to whole group with summary of students findings.
2. Writing realistic job descriptions.	Read and comment on students' descriptions. With individual's permission, read out selection to whole group and invite comparisons with job descriptions in newspaper.
3. Contacting a journeyman or apprentice	Supply names and encourage students to come up with own contacts. If necessary, two students could team up to make a visit.
	Role play telephone contact and get students to copy out suggested questions. Make individual contract with each student, setting deadlines to call, to visit and to report back. Check on progress and share with rest of group.
4. Asking questions	Arrange for individuals to report back to whole group at same session.
5. Making a group visit	Go over observations and questions beforehand. Ask students to write questions down. Divide questions, and order of asking, among group. Add any other questions suggested by group.
6. Reporting back	Ensure that each student records his or her observations. Invite individuals to report on their feelings and findings.
7. Discussion	Lead group discussion on overall findings.

3.9 Resumes A. Nature and function 1. Self advertisement 2. Summary of strengths and skills 3. Different ways to use resumes 4. Contrast application forms B. Extracts from resumes 1. People with little work experience 2. Presenting the best interpretation of the facts C. Suggested format 1. Position desired a. finding out about the job b. matching your skills 2. Education 3. Relevant work experience 4. Other relevant experience 5. Personal data 6. References a. making a list of your achievements D. Identification of your skills 1. Personal and interpersonal skills 2. Skills used in leisure and work activities a. what could go wrong b. what skills you need to avoid mistakes c. stamp collecting d. planting a garden E. A professional finish 1. Typing 2. Paper	Arrange another worksite visit. ILS Survivial Skills-Finding a Job-Resumes PREPARATION AND MATERIALS Large pad of newsprint and sufficient markers for group. Ensure that there are adequate flat surfaces.

F. Cover letter
1. Why them?
2. Why you?
3. Let's meet

G. Self Assessment
1. Personal and interpersonal skills

2. In a job context

3. Analyze three examples of work

H. Post Assessment
1. Organizing personal work experience

HELPING WITH ASSIGNMENTS

Be available throughout, when students are working on Self and Post Assessment. Write on chalkboard further suggestions of personal and interpersonal skills.

Suggest students help each other in finding relevant examples of their application of skills.

Allow partners to choose each other. Emphasize broad definition of work to include paid and unpaid, part-time, etc. Give examples.

Model how students can help each other. Go around and ask questions to elicit relevant information.

Supply sheets of newsprint and markers. Tell students to use the full area of paper. Check that students are recording all the suggested information.

Inspect sheets individually and suggest best way to organize data. Advise on where to include or omit dates and which experience to group or

2. Writing a draft resume	separate. Give encouragement and direct help with drafting of resume. Take best draft, type it and duplicate it on quality colored paper. With permission of student, share with whole group. Encourage sharing of draft resumes. Offer to help later if individuals want to develop a finished version of resume.

3.10 Interviews

A. Subjective nature of interviews
   1. Content of hiring interviews
   2. Interviewers' opinions
   3. Interviewees' opinions

B. Facts and opinions
   1. Giving honest opinions
   2. Interpreting facts
   3. Quoting references and examples
   4. Deciding what is relevant

C. Employers' expectations
   1. Objective measures of aptitude and achievement
   2. Appropriate attitudes and work habits

D. How to communicate interest and enthusiasm
   1. Be genuine
   2. Be informed
   3. Showing enthusiasm
      a. non-verbally
      b. how to speak and what to say

E. How to communicate that you will be a good worker
   1. Finding examples

F. How to show you are trainable
   1. School and non-school

G. How to show you work well with people
   1. Relations with the interviewer
   2. Giving examples

H. How to be realistic about what you want
   1. Knowledge of the work environment
   2. Knowledge of the career structure
   3. Answering questions about goals

ILS Survival Skills-Finding a Job-Interviews

PREPARATION AND MATERIALS

Read material beforehand and recall examples from own experience. Have two copies of observers' checklist for each student.

I. Appearance
  1. Clothes
  2. Grooming

J. Non-verbal behavior
  1. Punctuality
  2. Nervousness
  3. Body posture
  4. Gestures
  5. Smoking and chewing

K. Being positive
  1. About yourself
  2. About others

L. Self Assessment
  1. Role play
    a. interviewer
    b. interviewee
    c. observer
  2. List of questions
  3. Checklist

M. Post Assessment
  1. Interview in front of the group
  2. Questions from Joint Apprenticeship Committee
  3. Giving positive feedback

FORM TRIADS

Go through checklist to ensure understanding. Choose best working groups. Keep it moving by limiting time for each role play. Be willing to model positive answers in interviewee's role.

Ask for a volunteer, then allow him or her to select next interviewee. Suggest use of observer's checklist, plus any other positive comments. Give feedback from group and yourself, immediately after each interview. Invite interviewee to share his or her feelings experienced during role play.

3.11 Appropriate work habits and attitudes A. Surviving on the job. 1. Keeping informed	ILS Survival Skills-Finding a Job -Appropriate Work Habits and Attitudes BE A RESOURCE Share personal experience with individuals. Encourage students to ask any older people about work habits and attitudes. Give time for sharing students' findings.
B. Employer's expectations 1. Being punctual and dependable 2. Being honest 3. Being loyal 4. Being willing to learn and able to take criticism	Show relevance of previous modules to both 2 and 3. Ask individuals what expectations a member of Survival Skills class has.
C. Expectations of fellow workers 1. Proving your competence 2. Being reliable and dependable 3. Being a learner 4. Being enthusiastic and interested 5. Being honest and loyal	POSSIBLE DISCUSSION What do individuals expect of friends? What are peer group's attitudes toward 4?
D. Proving your competence to your supervisor 1. High standard of work 2. Keeping a written record of your achievements 3. Showing initiative 4. Taking on responsibility 5. Asking for help	
E. Interference of personal habits 1. Substance abuse 2. Seeking help	Be sensitive to possibility of substance abuse affecting student performance. Learn physical indicators; have referral addresses available.

F. Self Assessment

G. Post Assessment

Check comprehension.
Tell students to repeat reading and doing Post Assessment until acceptable standard is reached.
Discuss with individuals any disagreements over appropriate answers and be flexible.

SUGGESTED READINGS:

Alberti, R.E. and Emmons, M.
Your Perfect Right
Impact, 1974.

Blicq, Ron
On the Move: Communication for Employees
Prentice-Hall, 1976

Bolles, Richard N.
The Three Boxes of Life
Ten Speed Press, 1978

Fast, Julius
Body Language
Pocket Books, 1971

Chapman, Elwood N.
Your Attitude is Showing: A Primer on Human Relations
Science Research Associates, 1972

Ford, George A.
Planning your Future: A workbook for Personal Goal Setting
University Associates, 1976

McCay, James T.
The Management of Time
Prentice-Hall, 1977

Nelson, Robert E.
Decision Making
Vision Publishing, 1976

Peale, Norman V.
The Power of Positive Thinking
Prentice-Hall, 1952.

4.0 Trade Math

INSTRUCTIONAL OUTCOMES: The student will complete a diagnostic examination to determine his or her level of math competency, and will receive instruction in those areas of mathematics in which he or she experiences difficulty.

INTRODUCTION: People in every apprenticeable occupation routinely use mathematics in their work. The skilled worker who can perform fast and accurate math calculations can work quickly and efficiently.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
4.1 Math Diagnosis A. Used to test skills 1. Math diagnostic exam, attached, or other suitable exam.	Explain "placement exam" concept Administer exam Grade performance
4.2 Math Remedial A. Used to upgrade skills 1. Modules, as listed, improve performance levels.	Assist student to achieve performance level

ILS	Math--Linear Measurement	
ILS	Math--Whole Numbers Addition Subtraction Multiplication Division	
ILS	Math--Addition & Subtraction of common fractions and mixed numbers	
ILS	Math--Multiplication & Division of common fractions and whole and mixed numbers	
ILS	Math--Compound numbers	
ILS	Math--Percent	
ILS	Math--Ratio and Proportion	
ILS	Math--Decimals Addition Subtraction Multiplication Division	
ILS	Math--Perimeters Areas and Volumes	
ILS	Math--Circumference and Area of Circles	
ILS	Math--Areas of Plane Figures, Volumes of Solid Figures	
ILS	Math--Metrics	

4.0 Trade Math Diagnosis
Placement Test

Name _____

Date _____

1.

Read the distance from the start of the ruler to the letters A through O to the nearest 1/32".

A=_____ F=_____ K=_____

B=_____ G=_____ L=_____

C=_____ H=_____ M=_____

D=_____ I=_____ N=_____

E=_____ J=_____ O=_____

2.

686 + 240 + 1,320 + 16 + 400 =

40 - 16 =

292 X 16 =

180 ÷ 5 =

A contractor buys 400 sacks of rock for three different jobs. On the first job he uses 78 sacks; on the second, 85 sacks; and on the third, 205 sacks. How many sacks does he have left?

A contractor's bid on a school building is $78,265. When one wing is omitted to cut costs, he is able to cut his bid by $16,228. What is his new figure?

3.

If a bundle of rock lath weighs 35 lbs. and it is permissible to place 700 lbs. on any one area on a floor, how many bundles can be placed on any one area?

If 5 lbs. of putty are required to install one light of glass, how many lights can be installed with 85 lbs.?

One-third of a box of glass is needed to glaze the north elevation of a building; 2/3 of a box is needed to glaze the south elevation; 1/16 of a box is needed to glaze the east elevation; and 1/2 of a box is needed to glaze the west elevation. How many boxes are needed to glaze all four elevations?

From a bundle containing 101 linear feet of molding, a cabinetmaker uses the following amounts: 11 1/3', 8 3/4', 12 1/8', and 9 5/8'. How many linear feet of molding does he use in all?

6.

The product of 1/2 X 7/8 is:

The quotient of 1/4 ÷ 1/3 is:

If a roll of carpet weighs 467 1/2 lbs. and a running foot of the carpet weighs 2 1/8 lbs., how many running feet are in the roll?

A piece of pipe must be cut to 3/8 the length of another pipe, which is 9' long. How long a piece must be cut?

An architect indicates a 1/8" = 1'0" scale in the drawing of a swimming pool. What is this scale expressed as a ratio?

On a tile job in which fireclay is to be used, a tilesetter tells his helper to mix mortar according to the following formula: 6 buckets of river sand, 1 bucket of fireclay, and 2 buckets of cement. What is the ratio of sand to fireclay in the mixture?

9.

Divide 19' 2" by 3' 10".

How many pieces of 2' 3"-wide gypsum lath will be needed to cover a wall 48' 6" long?

10.

What is the perimeter of a room 20' wide and 30' long?

What is the area, in square feet, of a floor 42' by 42'?

How many cubic yards of dirt have been removed for the basement and foundations of a house if the excavation is 35' long, 35' wide, and averages 5' deep?

The area of a circular putting green with a radius of 17' is how many square feet?

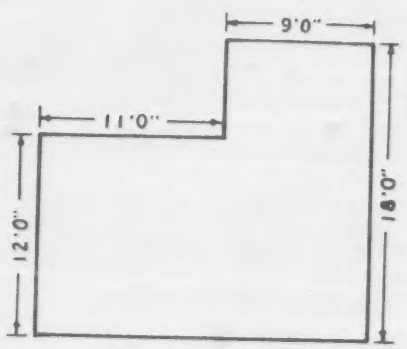
What is the area of a circular floor with a diameter of 10' 6", to the nearest square foot?

What is the area, in square inches, of an acute triangle with a base of 8 1/2' and an altitude of 11 1/4"?

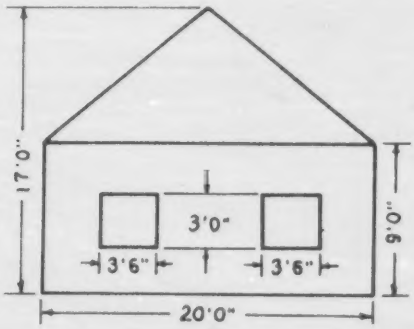
What is the area in square feet, of the floor shown below?

How many cubic yards of concrete will be needed for the foundation walls and footings in the plan below if the walls are 6" thick and 18" deep, and if the footings (shown in dotted lines) will require 2 5/27 cu. yd. of concrete?

1. 6
2. 6 2/3
3. 7
4. 7 1/6



What is the total area, in square feet, of the exterior wall and gable shown below, excluding window areas?



11. Metrics

3 inches	=	cm
5.4 inches	=	cm
7 feet	=	m
3.2 feet	=	m
6.5 yards	=	m
15.3 m	=	inches
12.7 cm	=	inches
50.8 mm	=	inches

5.0 Physical Requirements/Welding

INSTRUCTIONAL OUTCOMES: The student will demonstrate knowledge of physical requirements of the trade and the processes of physical development.

INTRODUCTION: The trade requires certain physical skills and abilities of the worker. It is necessary that the student be aware of the physical demands of the trade and understand factors of physical development.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
5.1 Physical Requirements A. Strength 1. Lifting. a. material and equipment; weights will vary with job. 2. Carrying. a. tools, equipment and materials; weights will vary with job. 3. Pushing. a. aligning pieces to be fabricated. 4. Pulling. a. moving gas tank cart.	On-site visit or classroom simulation. A. Demonstrate B. Lead discussion or question on job site C. Discuss proper technique D. Administer work sheet

B. Balance
   1. Climbing.
      a. ladders/scaffolding on large or elevated work.
   2. Balancing.
      a. while on ladders/scaffolding.

C. Body Dexterity
   1. Stooping.
      a. welding near floor.
   2. Kneeling.
      a. welding on floor surface.
   3. Crouching.
      a. checking welding near floor level.
   4. Crawling.
      a. depends on job.
   5. Standing.
      a. depends on job.
   6. Sitting.
      a. depends on job.
   7. Walking.
      a. movement around jobsite.
   8. Reclining.
      a. depends on job.

D. Manual Dexterity
   1. Reaching above shoulder.
      a. overhead welds.
   2. Reaching below shoulder.
      a. low level welds.
   3. Handling.
      a. grasp torch.
   4. Fingering.
      a. operating tank/torch valves.
   5. Feeling.
      a. weld surface at joints.

E. Talking
   1. Normal communication.

F. Hearing
   1. Normal communication.

G. Vision
   1. Normal vision.
      a. movement about job site.
   2. Acuity near.
      a. joint alignment/weld continuity.
   3. Color vision.
      a. flame color.

H. Coordination
   1. Hand-arm.
      a. use of welding torch.
   2. Foot-leg.
      a. climbing ladder.
   3. Eye-hand-foot.
      a. welding while on raised platform or ladder.

PHYSICAL ACTIVITIES PRESENT IN THE TRADE: REQUIREMENTS (to be completed by student)

STRENGTH	Weight	Frequency	BODY DEXTERITY	Degree of Activ.	Frequency	MANUAL DEXTERITY	Degree of Activ.	Frequency
Lifting			Stooping			Reaching-above shoulder		
Carrying			Kneeling			Reaching-below shoulder		
Pushing			Crouching			Handling		
Pulling			Crawling			Fingering		
BALANCE	Need	Frequency	Standing			Feeling		
Climbing			Sitting			TALKING (speech)		Frequency
Balancing			Walking			HEARING	Acuity	Range
VISION	Need	Frequency	Reclining			COORDINATION	Degree	Frequency
Normal vision			VISION (Cont'd)			Hand-arm		
Acuity-near			Color vision			Foot-leg		
Acuity-far			Field of vision			Eye-Hand-Foot		
Depth perception								

5.2 Individual Developmental Processes A. Maturation 1. Causes physical changes in height and body proportion. 2. Causes emotional changes. 3. A gradual process. 4. Fluctuates from person to person. B. Nutrition 1. Vital to normal growth and development. 2. Essential food groups. a. dairy products. b. meat. c. vegetables and fruits. d. bread and cereals. C. Personal Care and Exercise 1. Good grooming habits. 2. Sufficient sleep and relaxation. a. fatigue increases chances for accidents. 3. Hobbies. a. source of relaxation, help to maintain good attitude. 4. Daily exercise. a. stimulates interest. b. relieves stress. D. Substance Abuse 1. Marijuana. a. affects nervous system. b. affects thinking, judgment and coordination. c. long-term effects unknown.	ILS Physical Development Explanation and Discussion Invite Specialist

2. LSD. a. affects chemical level in brain. b. produces bizarre mental reactions. 3. Barbiturates. a. one of most commonly abused drugs. b. slow responses. c. physically addicting. d. long-term use causes personality disorders. 4. Amphetamines. a. affect central nervous system. b. commonly abused. c. cause psychological dependence. d. dull emotions and impair ability to make decisions. 5. Alcohol. a. psychologically addicting.	
E. Meeting Various Trade Requirements 1. Recognize and prepare. a. natural maturation processes may play role. b. exercise will play role.	On-job-site visitations and consultation with occupational therapist.

6.0 Safety

INSTRUCTIONAL OUTCOMES: The student will be able to identify those hazards, acts and conditions which affect safety on the job and will be able to identify ways to avoid or correct them.

INTRODUCTION: A good worker is a safe worker; injury affects production, as well as the ability of a person to earn a living.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
6.1 General Safety Precautions A. Always keep oxy-acetylene cylinders in upright position. B. Mount cylinders on wheeled cart or install in upright, permanent position. C. Secure cylinders to cart with chain D. Don't store cylinders near excessive heat E. Always leave protective cap on cylinders when handling and transporting F. Avoid rough handling; oxygen cylinders have total pressure force of 30 tons; if	ILS W 2001 ILS W 2005 Explain, discuss and discuss

ruptured, have rocket's actions

G. Never use leaking cylinder

H. Always run oxygen through regulator.

I. Keep cylinder fittings free from oil or grease; will form compound which can ignite.

J. Never oil any equipment or regulators

K. When testing for leaks, use soapy water and soft brush.

L. Never use oxygen to blow off clothes.

M. When opening oxygen cylinder valves, stand to one side and open first turn very slowly; high pressure in cylinder may blow out gauge.

N. Never light torch with both valves open; light acetylene first.

O. Always use striker to light torch; never matches.

P. Always wear goggles.

Q. Never strike arc on oxy-acetylene cylinders.

R. Acetylene is unstable at pressures above 15 psi; never allow pressure to rise above that level.

S. Use correct hoses for each gas; red for acetylene, green or black for oxygen.

T. Use only proper size wrench for all fittings; they are brass and will be damaged or ruined if corners are rounded off.

U. Always open oxygen valve completely to avoid leakage around stem.

V. Never open acetylene cylinder valve more than 1½ turns.

W. Leave acetylene cylinder wrench in place to ensure ability to close rapidly in case of fire.

7.0 First Aid

INSTRUCTIONAL OUTCOMES: The student will successfully complete an eight-hour multi-media first aid class, taught by a qualified instructor, and will obtain a First Aid Card.

INTRODUCTION: Persons employed in any occupation, especially those occupations which deal with power and hand tools, encounter situations when first aid may be necessary to prevent an injury from becoming more serious. A first aid course, successfully completed, prepares individuals to cope with many of those situations.

PRESENTATION

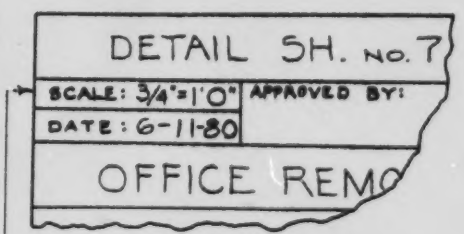
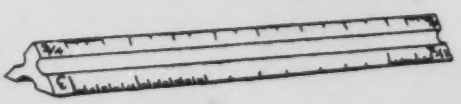
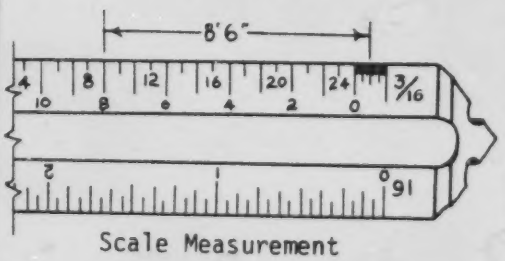
TEACHING OUTLINE	TEACHING METHODS AND AIDS
7.1 First Aid A. Eight-hour multi-media course, or equivalent, offered by: 1. Red Cross 2. Medical Services, Inc. 3. Police Department 4. Fire Department 5. Other service and health organizations.	Administer course

8.0 Blueprint Reading

INSTRUCTIONAL OUTCOMES: The student will be able to identify and use the concepts of working drawings and their components: scaling and dimensioning, sketching, orthographic, pictorial and isometric projections, as well as construction symbols commonly found in blueprints.

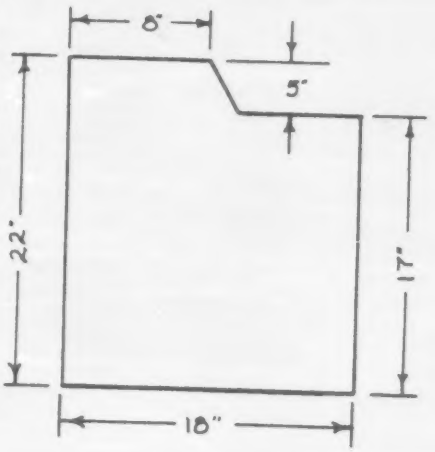
INTRODUCTION: A skilled worker must understand the language of blueprints to advance in any trade where prints are used.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
8.1 Scaling and Dimensioning A. Scale 1. The ratio of drawing dimensions to object dimensions. 2. Always indicated on drawing. 3. Vary, depending on size of paper and detail to be shown. 4. Measured by architect's scale, engineer's scale, draftperson's scale. 5. Technique of measurement: architect's scale is placed on drawing, read in marked increments.	 Scale as Shown  Architect's Scale  Scale Measurement

B. Dimensions

1. Are size descriptions for drawn objects.
2. Located on working drawings by:
   a. dimension lines--indicate distance between two points (usually between two extension lines); contain dots or arrows at ends.
   b. extension lines--mark the beginning and end of distance.
3. Placed in orderly fashion on drawing.



Dimensions

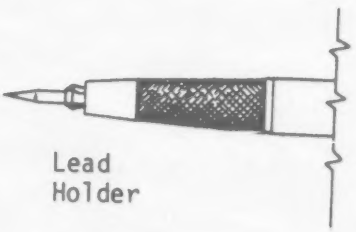
8.2 Sketching

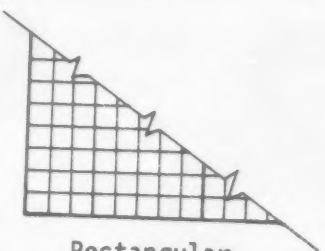
A. Uses

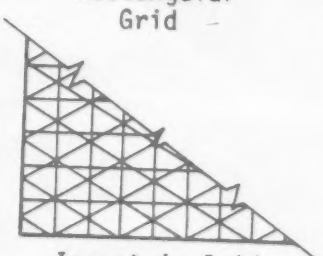
1. For conveying rough ideas or organizing ideas.
2. For details, developed from existing drawing.

B. Materials

1. Pencil, soft lead.
2. Eraser, gum.
3. Paper, coordinate.
   a. rectangular grid
   b. isometric grid


Lead Holder


Rectangular Grid


Isometric Grid

C. Size, Proportions

1. Generally not drawn to scale, but should remain proportionately accurate.

D. Procedures

1. Determine overall size of object.
2. Create short lines by one firm, quick stroke.
   a. go through motion of stroke with pencil removed from paper.
   b. pencil point on paper entire time.

E. Basic Forms

1. Squares, rectangles, triangles, circles.
2. Layout crosses (intersecting lines) to provide reference points for drawing.
3. Circles and arcs sketched with little finger of drawing hand as pivot; move paper, not hand.

8.3 Drawing Types and Views

A. Orthographic Projection

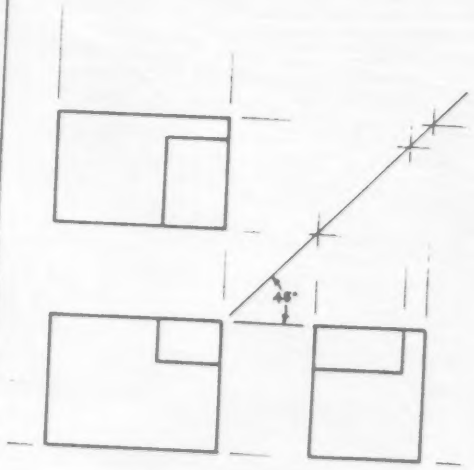
1. Called orthograpic drawings or "true" drawings, also "three-view" or "multiview."
2. Almost universally used in architect and engineer drawings.
3. Drawn to scale.
4. Each view shows one face or side of object as seen from square view.
5. Possible to indicate true size, shape and location of all object parts, and dimension clearly.

Explain and Discuss;
All References made to:

ILS Scaling and Dimensioning

ILS Sketching

ILS Types of Drawings and Views

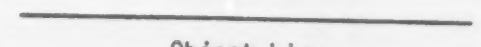


Orthographic Drawing

6. Each view is 90^{0} rotation of other view.
7. All related views must be studied together to visualize object shape.

B. Types of Lines
   1. Border Line.
      a. a thick, solid black line (blue).
      b. shows geographical or space borders.
   2. Visible object line.
      a. a thinner solid black line (blue).
      b. shows visible edges of object.
   3. Hidden object line.
      a. a line of equidistant and equal length dashes.
      b. shows edges of important elements hidden from view.
   4. Section line.
      a. a thick, broken line with arrows turned at 90^{0} angle.
      b. delineates sections of object represented.
   5. Center line.
      a. a thin line of alternately long and short dashes.
      b. shows centers of objects (doorways, e.g.) and relationship with given dimensions.

Border Line



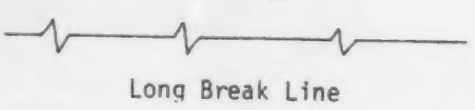
Object Line

Hidden Object Line

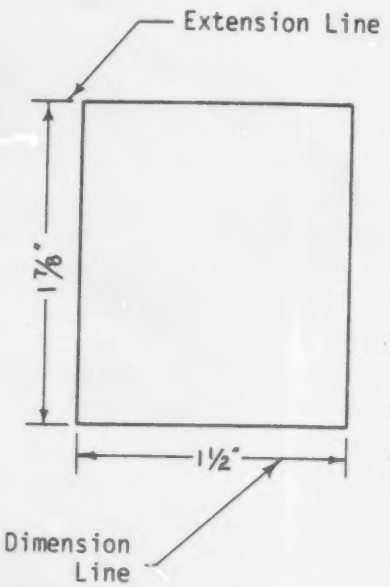
Section Line

Center Line

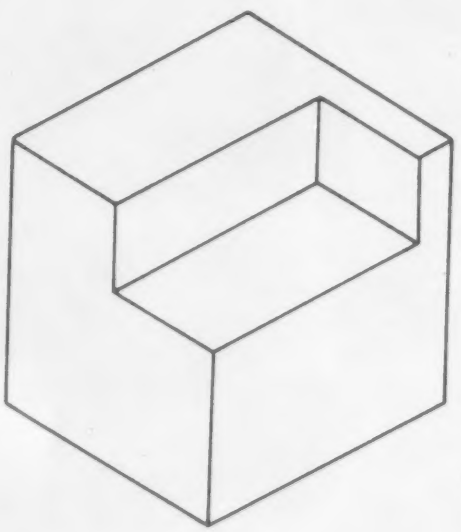
6. Long break line.
   a. a thin solid line, straight, with occasional zig-zags.
   b. indicates a break in object.
7. Extension line.
   a. a short thin line, drawn perpendicular to dimension line.
   b. shows beginning and ending point of measurement; lines are extensions of object or part.
8. Dimension line.
   a. a long thin line, with dots or arrows on each end, broken in middle for numbers.
   b. touch extension lines and give measurement from one extension line to another.



Long Break Line



C. Pictorial Drawing
   1. Shows more than one face of object.
   2. Advantage: easier for lay person to understand.
   3. Disadvantage: distorted object lines and angles.
   4. Useful to give "completed" look renderings.



Isometric Drawing

D. Axonometric Drawing

1. A type of pictorial drawing.
2. Three principle axes used.
3. Can represent any object by changing viewpoint.
4. Isometric position is principle one used.

E. Isometric Drawings

1. Viewed from exact position in which three of sides are equally foreshortened.
2. Three axes: one axis vertical and other two at 30^{o} from horizontal base.
3. Will appear in true proportion.
4. Will not appear in true scale lengths.

9.0 Equipment/Welding

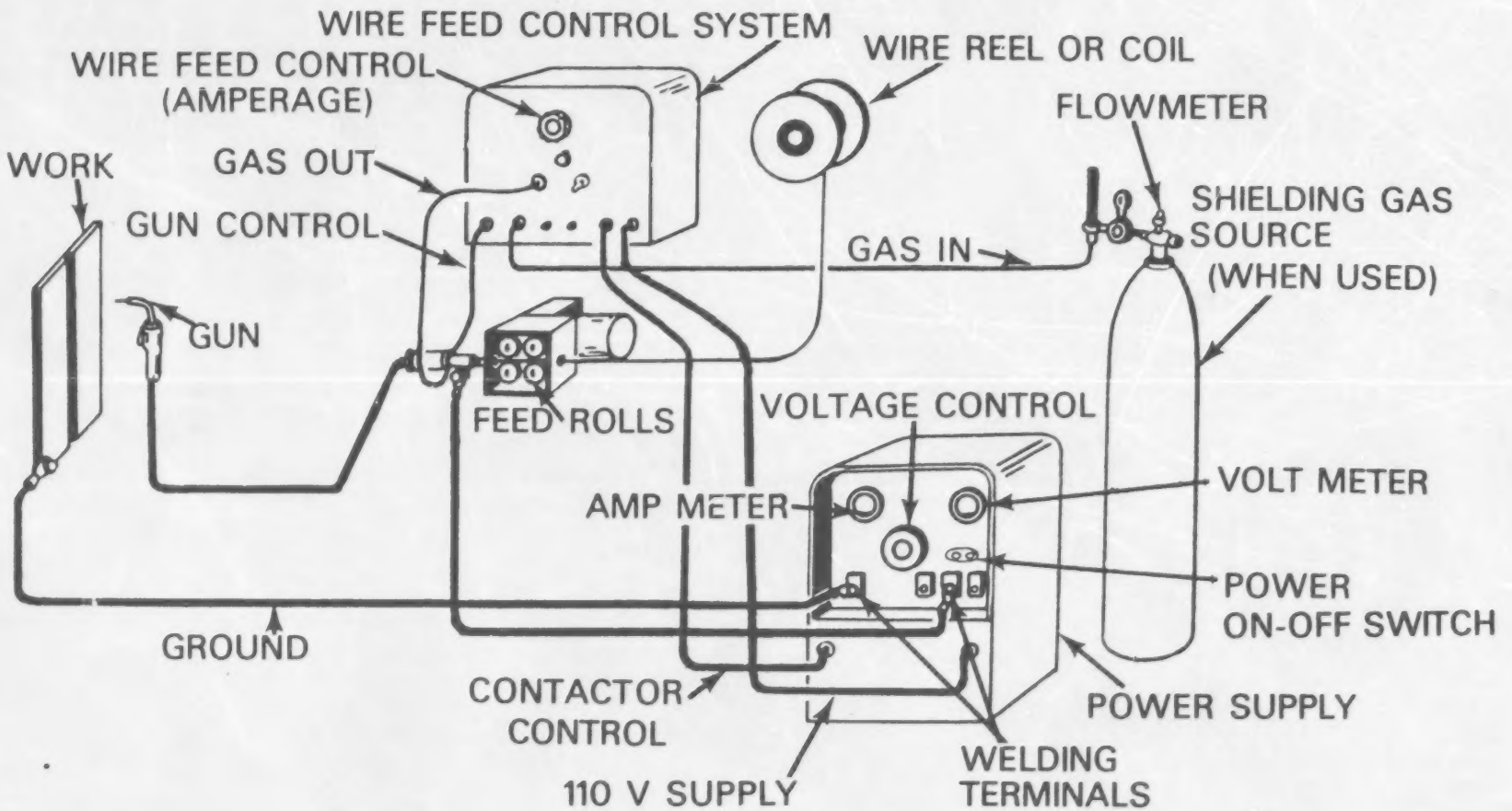
INSTRUCTIONAL OUTCOMES: The student will be able to describe the general characteristics of welding.

INTRODUCTION: The welder must develop skill in various welding processes if he or she is to be skilled in the welding trade.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
9.1 Equipment 9.1.1 Gas Metal Arc Welding--MIG A. Operation 1. Uses consumable wire which is fed through a gun at a continuous rate in a gas shielded atmosphere. 2. The wire carries the current and is the electrode. 3. Advancing wire is melted by high temperature electric arc to form globule of molten metal for filling the weld. 4. Can be automatic or semi-automatic.	Overhead Master GMAW Process

GMAW Equipment

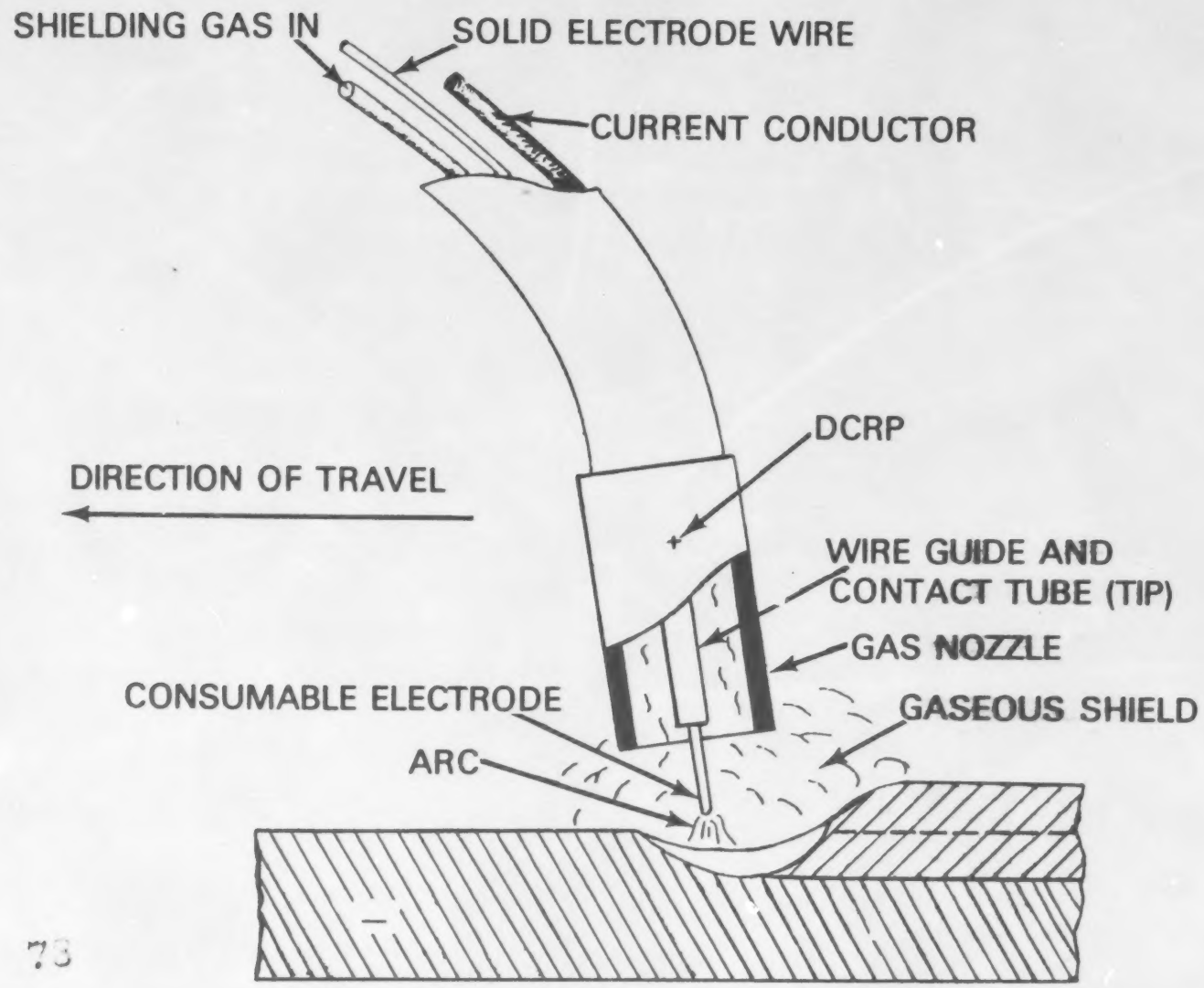


*DCRP- MOST GTAW APPLICATIONS

(NOTE: SOME FLUXCORED GTAW IS DONE WITH DCSP)

B. Power Supply--Rectifier Containing 1. AMP meter--displays amperage or current being used. 2. Volt meter--displays voltage available. 3. Voltage control--turn to set desired voltage. 4. Power switch--turn power supply on/off. 5. Welding terminals--connection for ground and gun cables. 6. Voltage supply to wire feed system.	Overhead Master GMAW Equipment
C. Wire Feed Mechanism 1. Contains controls for: a. wire feed; sets amperage and rate of wire feed by turning a knob. b. gas solenoid; activates gas flow when machine is on. c. water control; supplys water for cooling water-cooling gun. d. feed rolls; drives wire from reel to gun when gun is turned on. e. power contractor; cable from wire feed control panel to power supply allowing wire feed machanism to be placed in remote location from power supply. f. wire reel; filler metal in wire form is rolled on spool and fed through mechanism to gun from the reel. 2. Welding gun. a. manually operated gun with trigger control. b. delivers wire, gas, and current to welding area. c. cooled in two ways:	ILS W5001

GMAW Process



(1) water; used with current above 200 AMPs. (2) air; for welding light gage metal using less than 200 AMPs. d. types: (1) push; for larger diameter wire. (2) pull; for smaller wire, commonly called micro-wire. 3. Shielding gas. a. usually supplied in a tank or cylinder. 4. Flow meter. a. valve and regulator to adjust supply of gas at required rate. 5. Consummable wire. a. filler wire having similar composition as metal to be welded; usually available in several diameters and is wound on a spool or reel.	
D. Gases 1. Different types and thicknesses of metal require different gases to insure smoothness of operation, good weld appearance and quality and maximum welding speed. 2. Important welding gases used in mig welding. a. argon. (1) provides a stable arc, reduces splatter, uses low arc voltage. (2) recommended for welding aluminum, copper, nickle, titanium b. argon plus oxygen (oxygen up to 5%).	ILS W5001

(1) improves penetration, better weld contour, reduces undercutting.

(2) used for low alloy steels, carbon steels, stainless steel

c. carbon dioxide.

(1) a broad, deep penetration pattern is obtained, good bead contour, eliminates undercuts, low cost, avoids weld spatter problems due to violent arc.

(2) weld low carbon steel.

d. argon plus CO_2 (up to 80% CO_2).

(1) improved weld appearance, reduced spatter, reduced cost.

(2) used for mild steel, low alloy steel, some stainless steel.

E. Metal Transfer — ILS W5001

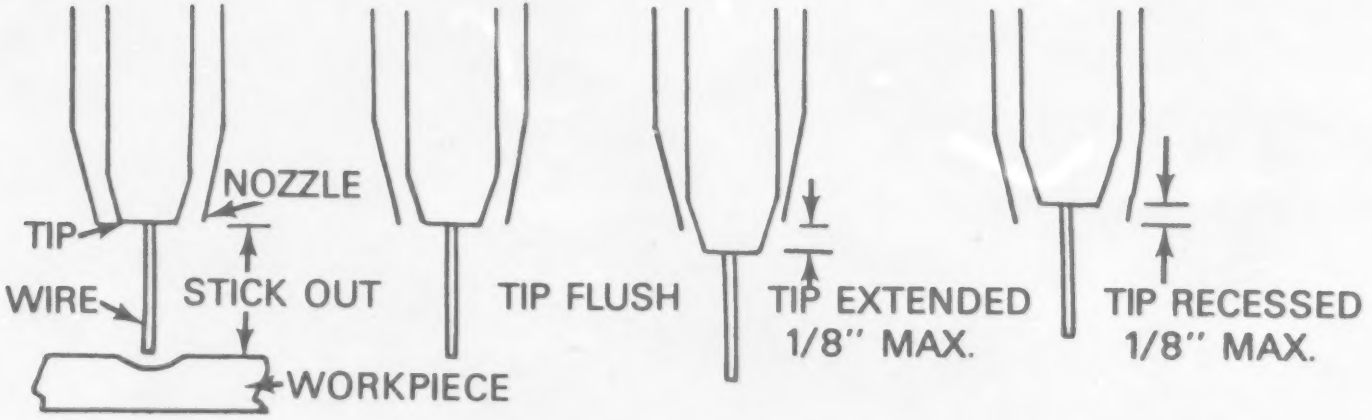
1. Metal is transferred in MIG process by one of two methods.

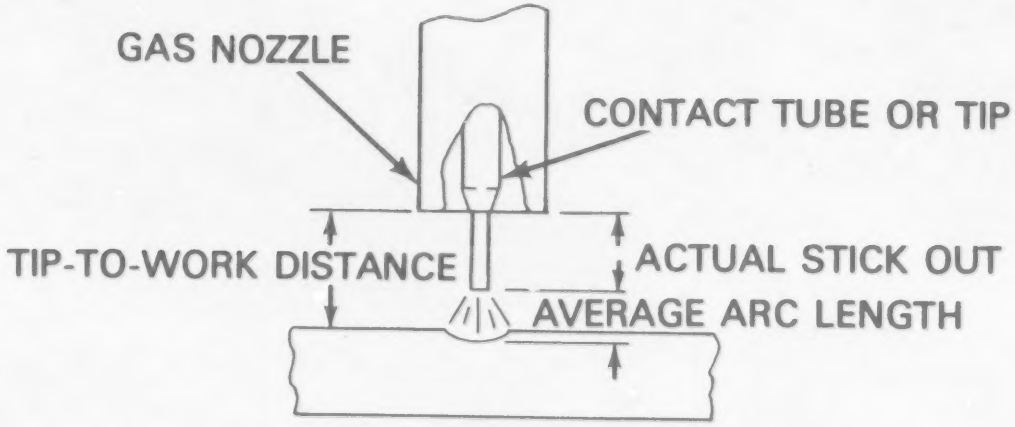
a. "spray arc"

(1) drops of molten metal move from wire electrode through arc column to work in argon or argon-oxygen shield.

(2) with carbon dioxide or argon-carbon dioxide shielding gas, a molten ball forms at end of electrode; when drops are larger than diameter of wire, it is called globular transfer.

GMAW Electric Wire Stick Out





(STICK OUT IS TIP-TO-WORK)

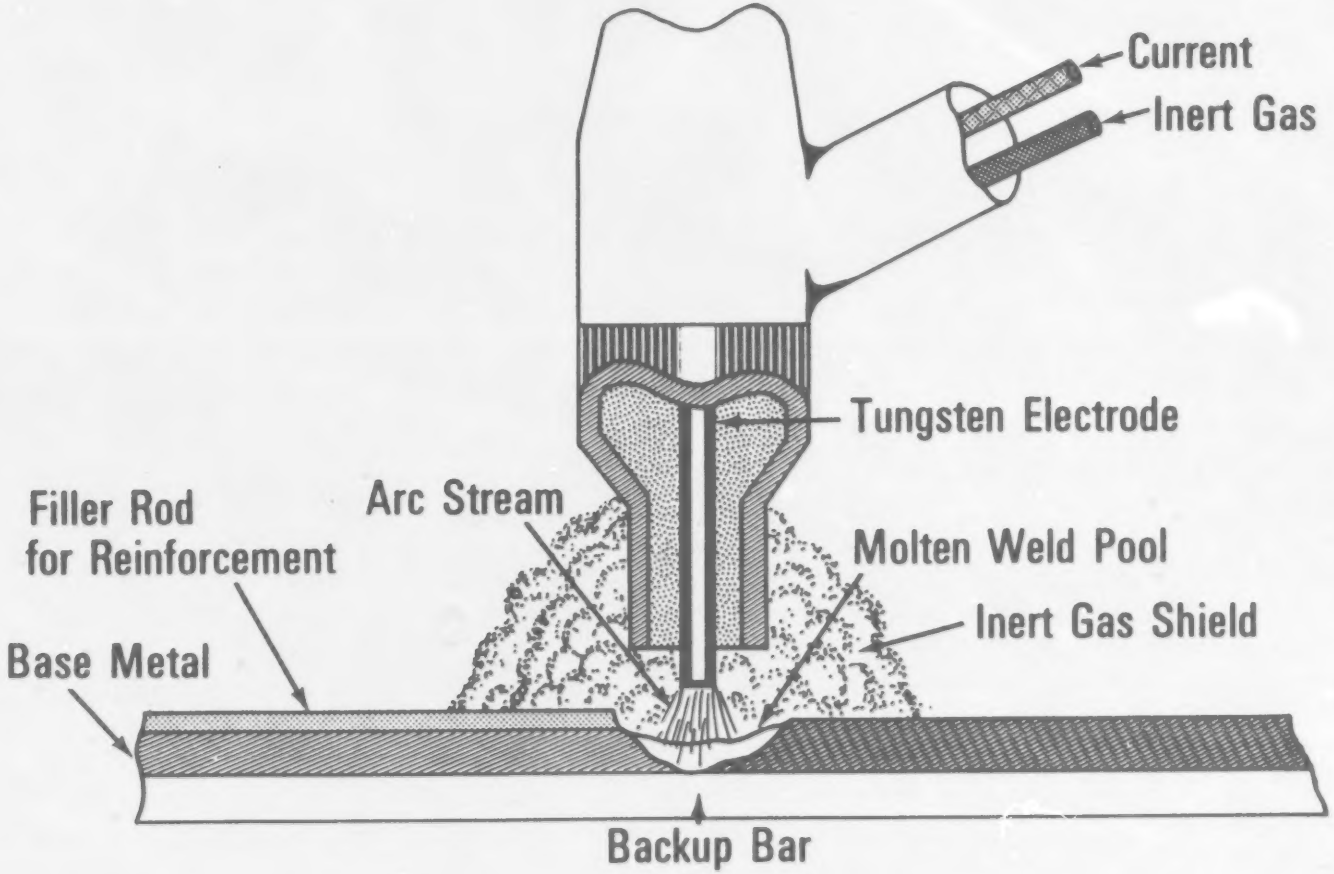
b. "short arc"
(1) uses low currents, low voltage, small wire diameter.
(2) shallow weld penetration is obtained; molten drop short-circuits arc average of 100 times a second; metal is transferred with each short-circuit.

F. Proper Sequence
1. Set voltage, wire feed and gas flow for type welding being done.
2. Adjust wire for proper amount of stick-out.
3. Start arc and move gun along seam at uniform speed, keeping gun at proper angle.
4. If filler wire sticks to metal or freezes to tip, turn off machine and free wire.
5. Release trigger at end of seam.
6. Shut off welding unit; sequence.
a. turn OFF wire speed control.
b. shut OFF gas flow at cylinder.
c. squeeze welding gun to bleed lines.
d. hang up welding gun.
e. shut off welding machine.

Welding Skills and Practices Overhead Master GMAW Electric Wire Stickout

9.1.2 Gas Tungsten Arc Welding--TIG (GMAW)
A. Power Supply
1. Constant current power source; may be AC (alternating current), DC (direct current) or combination AC-DC.

GTAW Process



2. Most TIG power sources are metal arc (stick electrode) power sources with special attachments.
3. Controls and parts.
   a. fine current adjustment; 5 to 500 AMPs turn to select correct amperage.
   b. remote amperage control; receptacle and switch for remote foot current control.
   c. polarity switch; selects straight or reverse polarity.
   d. contractor control; for additional equipment.
   e. coarse current selector; select low, mid, high current range.
   f. TIG torch connections; electrical supply to torch.
   g. gas after-timer; supplies gas shield to weld after torch is off.
   h. high frequency adjustment; turn for correct setting.
   i. high frequency switch; turns on high frequency generator for an even AC current supply.
   j. power switch; turns on machine.

B. Torches
   1. Air or water cooled, manually operated
      a. conduct both the welding current and inert gas to weld zone.
      b. air-cooled torch for low current and light gage materials.
      c. water-cooled for amperages over 200 AMPs.

d. holds non-consumable electrode rigidly by means of a collet which screws into body of torch; electrode is of tungsten. e. nozzle of torch is a ceramic cup of suitable size and shape for correct distribution of gas for shielding. C. Foot Control 1. When pressed with foot, both current and gas flow starts; current flow varies with foot pressure. D. Gas Cylinder and Regulator 1. Regulates supply of inert gas to torch E. Hoses 1. Used to supply gas and water to torch. F. Advantages and Disadvantages 1. TIG Welding. a. gas tungsten arc welding (GTAW) b. open arc welding, process in which metal is melted by an electric arc passing between a non-consumable tungston electrode and the base metal. c. molten metal is shielded from harmful atmospheric gases by blanket of inert gas fed through torch nozzle. d. shielding gas is usually argon, occasionally helium or argon-helium mixture.	ILS W4010 Welding Skills and Practices GTAW Equipment Process, Power Supply, Torch

e. shielding gas prevents oxidation of base metal and electrode.
f. filler metal is added in manner similar to oxy-acetylene welding process.

2. Advantages.
a. no after cleanup.
b. weld puddle clearly visible.
c. arc clearly visible.
d. no slag or spatter.
e. minimum distortion or stress.
f. very close control of weld current
g. excellent for pipe welding.
h. can weld many ferrous and non-ferrous metals.

2. Disadvantages.
a. equipment is more expensive and complex.
b. higher operating cost.
c. high degree of manipulative skill required.
d. nearly ideal welding conditions are required.

9.1.3 Oxy-acetylene Welding

A. Equipment Components

1. Acetylene cylinder.
a. acetylene gas is highly combustile.
b. unstable and explosive under 15 lbs. psi or more.
c. cylinder is filled with porous material and baked.
d. acetone is added to fill pores.

Overhead Transparency
Welding Equipment, Regulators, Torch
ILS W2001-2007

e. acetylene is then added under pressure; acetone absorbs acetylene and holds it safely at 250 lbs. or more.

f. cylinder has safety plug of low temperature lead which melts at 212° F. to allow gas to escape slowly and prevent explosion in case of fire.

2. Oxygen cylinder.

a. seamless drawn steel cylinders.

b. charged or filled with oxygen at pressure of 2200 psi for all sizes at 70° F.

c. sizes of cylinders; 224 cubic feet, 122 cubic feet, 80 cubic feet.

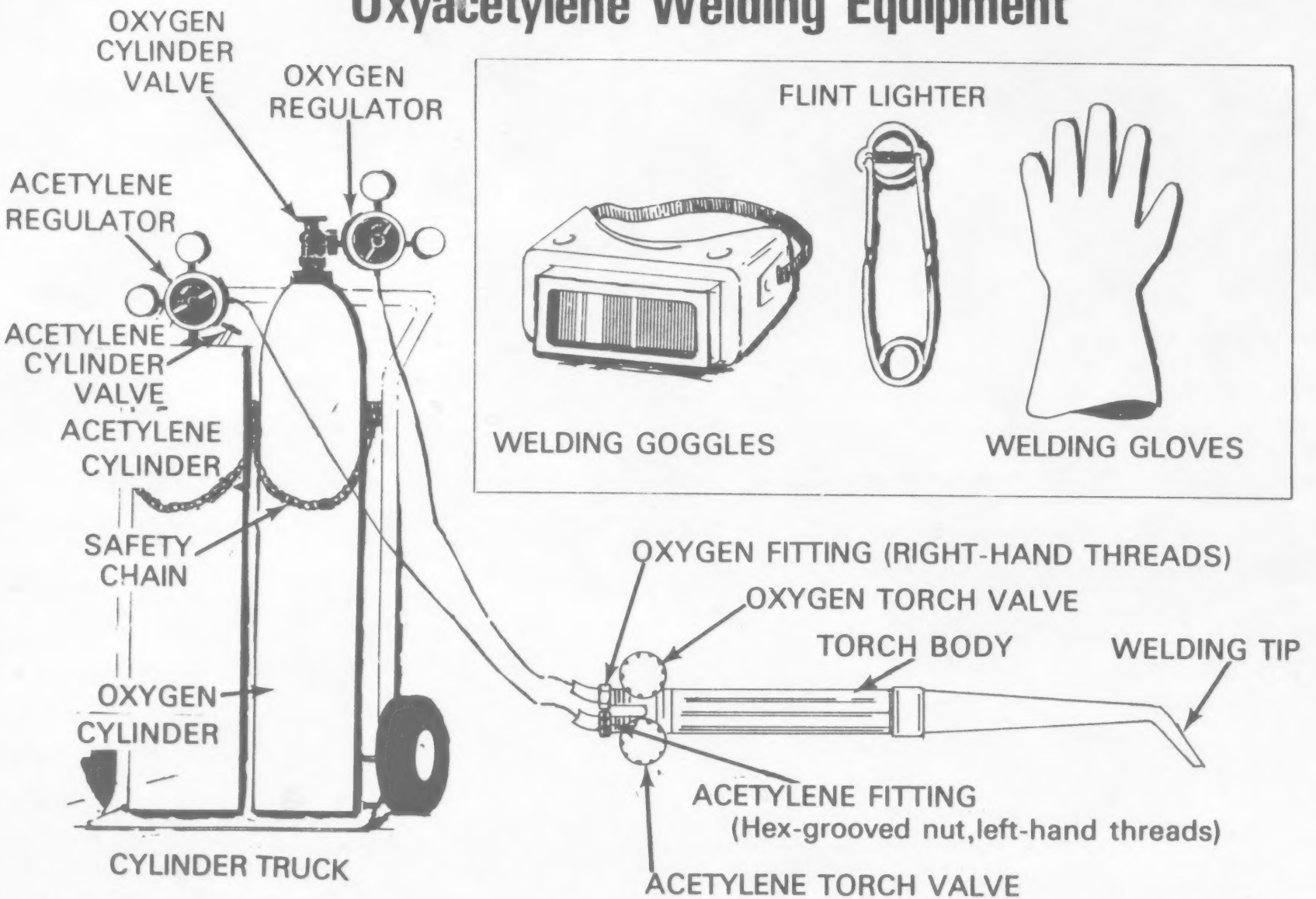
d. pressure of oxygen will increase or decrease with temperature; amount of gas remains the same.

e. protective cap screws onto cylinder ring to protect valve when moving or in transport; do not lift tank by cap.

f. safety nut on valve will slowly reduce cylinder pressure if it becomes too high.

g. safety disc in safety nut will burst at a pressure of 2840 pounds psi; it will melt at 240° F., allowing oxygen to escape through holes in safety nut.

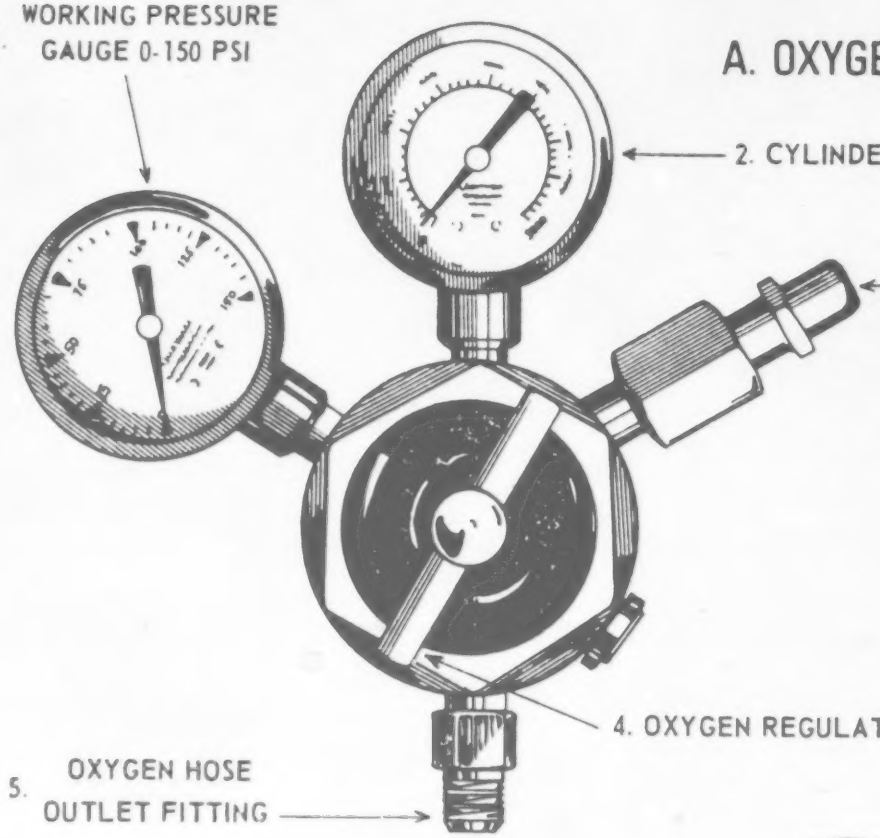
Oxyacetylene Welding Equipment



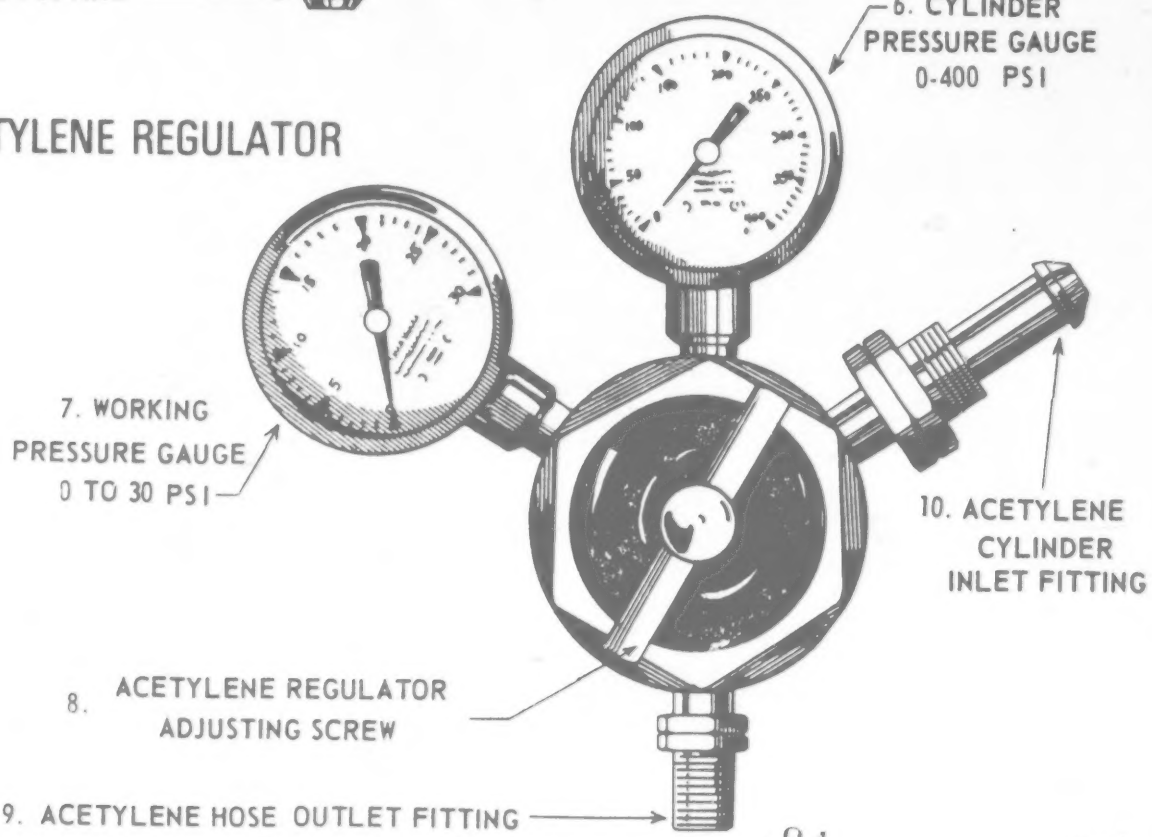
3. Acetylene and oxygen regulators. a. main purpose, to reduce very high cylinder pressure to low, safe, working pressure; also provides an even continuous flow of gas to torch. b. types of regulators. (1) single-stage; pressure reduced in one step or stage. (2) two-stage; pressure reduced in two steps or stages. c. cylinder gauges. (1) two gauges on each cylinder; one measures cylinder pressure one measures gas flow to torch	
4. Set of oxy-actylene hoses. a. hoses are color-coded: (1) red; acetylene; left-hand thread on fittings. (2) black or green; oxygen; right-hand thread on fittings. b. all fittings are brass.	W2002
5. Torch body and tips. a. torch mixes acetylene and oxygen in correct amounts and permits mixture to flow to end of tip. b. types of torches. (1) injector torch; for use with very low pressure acetylene. (2) equal pressure torch; used with cylinder gases. c. tips come in different sizes, measured by diameter of hole in end of tip.	W2007

Welding Regulators

A. OXYGEN REGULATOR GAUGES


1. WORKING PRESSURE GAUGE 0-150 PSI
2. CYLINDER PRESSURE GAUGE 0 to 3000 PSI
3. OXYGEN CYLINDER INLET FITTING
4. OXYGEN REGULATOR ADJUSTING SCREW
5. OXYGEN HOSE OUTLET FITTING

B. ACETYLENE REGULATOR


6. CYLINDER PRESSURE GAUGE 0-400 PSI
7. WORKING PRESSURE GAUGE 0 TO 30 PSI
8. ACETYLENE REGULATOR ADJUSTING SCREW
9. ACETYLENE HOSE OUTLET FITTING
10. ACETYLENE CYLINDER INLET FITTING

d. torch threads should always be protected by having a tip or cutting head attached.

B. Assembly of Equipment

W2002

1. Secure both cylinders (oxygen and acetylene) to a stationary object, or to a portable cart.
2. Remove steel valve-protecting caps.
3. Blow out any foriegn material which might have entered the valve by opening and closing valve quickly; referred to as "cracking the valve"; never stand in front of valve when "cracking."
4. Check oxygen cylinder valve outlet and regulator threads for damage, then attach oxygen regulator to oxygen cylinder; look for green color code, if any.
5. Check oxygen regulator pressure adjusting screw; should be turned out (counter-clockwise) which means regulator is off; open cylinder valve very slowly at first, then continue until wide open; stem is now sealed. Turn pressure adjusting screw in until a small amount of oxygen flows through hose opening; after cleaning out any dust, close cylinder valve and back off pressure regulating screw.

6. Follow same procedure with acetylene cylinder and regulator (with the exception that acetylene cylinder valve is opened only 3/4 turn); if tight threads are encountered, may be lubricated only with glycerin or soap.
7. Attach green or black hose to oxygen regulator.
8. Attach red hose to acetylene regulator.
9. Attach other end of hoses to fittings of welding torch and tighten all fittings with the proper wrench; always check threads for damage before threading.
10. Open oxygen cylinder valve very slowly at first, and then open all the way.
11. Open acetylene cylinder about 3/4 turn to assure fast shutdown in case of emergency.
12. Make sure torch valves are closed; turn pressure-adjusting screws clockwise until desired pressures show on the gauges.
13. Test for leaks with soap and water solution at following places.
    a. oxygen cylinder valve.
    b. acetylene cylinder valve.
    c. oxygen regulator connection.
    d. acetylene regulator connection.
    e. all hose connections.
    f. all hose to torch connections.
    g. welding tip connection.
    h. hoses, if worn places are evident.

i. apply solution with soft brush and watch for bubbles; if bubbles appear retighten and test; if leak persists, remove fitting, clean threads and seating surfaces, replace and retest.

C. Oxygen and Acetylene Regulator

1. Purpose.
   a. reduce high pressure of cylinder to low, safe working pressure.
   b. give an even, continuous flow of gas to torch.
2. Operation.
   a. high pressure gas enters regulator from cylinder into chamber of regulator.
   b. pressure in chamber rises until it overcomes pressure of a spring.
   c. diaphragm is deflected to right of valve and closes, preventing more gas from entering chamber.
   d. torch withdraws gas, dropping pressure in chamber, which causes diaphragm to move left and allows more gas to enter chamber.
   e. pressure adjusting screw is inserted to press on end of spring and varies tension to obtain any pressure desired.
3. Difference between oxygen and acetylene two-stage regulator.
   a. main difference is gauge readings or calibrations.

d. two-stage regulators identified by position of first stage mechanism on back of regulator, offset and not in line with adjusting screw.

5. Single-stage regulator.
   a. less expensive than two-stage.
   b. no intermediate chamber.
   c. gas from cylinder flows into regulator, controlled entirely by adjusting screw.
   d. disadvantage, as cylinder pressure drops, regulator pressure drops and occasional adjustment of pressure is necessary.

ILS W2006
Overhead Transparency Regulator

D. Manifold Regulator
   1. Purpose.
      a. to describe a manifold system.
      b. turning on and adjusting regulator
      c. turning off regulator.
   2. Description.
      a. manifold system is used to pipe gases stored in separate areas to welding area.
      b. in storage area one or more tanks may be connected to a line.
      c. reduces tank pressure to line pressure (manifold pressure) required at work area:
         (1) oxygen--50 to 60 psi.
         (2) acetylene--15 psi.

d. working pressure gauge and regulator and line valve are connected to gas line at work area; torch hoses are attached to regulators; no manifold gauge located in work area.

3. Turning on and adjusting.
   a. turn on line valve for gas to regulator.
   b. set regulator by turning adjusting screw (clockwise) on regulator to pressure required for welding.
   c. open corresponding needle valve (on torch) to determine if there is a drop in pressure on gauge.
      (1) if there is a drop in pressure set regulator adjusting screw to correct pressure.
   d. close needle (torch) valve.
   e. pressure on gauge will read higher with needle valve closed if a correction was made, but working pressure will be correct when welding.
   f. follow procedure for each gas regulator.
4. Turning off regulators.
   a. turn off acetylene torch (needle) valve; eliminates any small flame or soot.
   b. turn off oxygen needle (torch) valve.
   c. turn off line valves.
   d. turn both oxygen and acetylene regulator adjusting screws counter-clockwise until they turn freely.

ILS W2003

e. open needle valves on torch until pressure gauges read zero.
f. close needle valves.
g. hang up torch.

E. Torches and Tips
1. Torch parts.
a. body or torch handle; part held by operator.
b. needle valves; control gas flow to make adjustments to flame.
c. mixer; mix gases as they flow to tip.
d. welding tip; concentrate flame and direct it in desired direction; tips come in various sizes.
2. Torch types.
a. injector torch or blowpipe.
(1) designed to use with very low pressure acetylene (1 lb. psi or less).
(2) oxygen draws acetylene into oxygen stream.
(3) advantage; proportions of gas tend to remain constant, making it unnecessary to adjust gas to maintain required flame
b. equal pressure torch.
(1) most commonly used.
(2) used with cylinder gas.
(3) each gas is supplied at equal pressure, enough to force it into mixing chamber (3 lbs. acetylene requires 3 lbs. oxygen).

ILS W2007
Overhead Transparency Torch

3. Torch tips.
   a. size of tip is determined by size of hole at end of tip.
   b. size numbering system is determined largely by manufacturer; same-size tips may be marked differently if made by different manufacturer.
   c. use table to cross-reference tips for substitution (see attached table).
   d. tips accumulate carbon in interior and must be cleaned periodically.
4. Tip cleaning.
   a. use special tip cleaners.
   b. cleaners are a series of broach-like wires of same diameter as tip hole.
   c. select wire that corresponds in diameter to hole to be cleaned; use largest wire that easily enters hole.
   d. turn on oxygen to blow loosed particles from tip.
   e. insert tip without force; do not bell hole.
   f. remove by pulling straight out.
   g. repeat.
   h. if tip end is not square or is scarred, file end smooth, with square edges, before cleaning tip; file should be held at right angle to hole.
   i. light sanding with emery paper may be done before cleaning hole.

F. Lighting and Adjusting Torch Flame

1. Sequence.

a. assemble equipment and torch with tip.

b. have spark lighter or striker at hand.

c. set regulators at proper pressures.

d. turn acetylene needle valve on no more than 1/4 turn with torch pointed downward.

e. hold striker flash pan at an angle about one inch from tip.

f. squeeze striker handle to light torch immediately after turning on needle valve, to avoid large flash.

(1) if needle valve is opened too far, torch will not light, or will boom and pop out again; turn valve down.

(2) if needle valve is not opened enough, black soot will be evident; open valve.

g. with acetylene lighted correctly, continue to open valve until most black smoke disappears and stop before flame jumps away from tip.

h. slowly open oxygen needle valve. Three parts to the flame will become evident as oxygen is increased.

i. continue opening oxygen needle valve until center flame on feather just disappears now notice a well-defined white cone appear near tip, surrounded by bluish cone; this is called neutral flame.

ILS W2004
Overhead Transparency Welding Flames

2. Types of Flames.
   a. neutral flame; equal amount oxygen and acetylene.
      (1) commonly used in most welding and cutting operations; usually about 6000° F.
   b. carburizing flame; has excess amount of acetylene.
      (1) recommended for some welding techniques; lower temperature than neutral flame.
   c. oxidizing flame; adjusted with slight excess of oxygen.
      (1) inner cone is shorter flame; makes hissing sound; will burn steel, causes considerable sparking, used for braze welding and fusion welding of brasses and bronzes.
3. Turning off torch.
   a. turn acetylene valve off completely.
   b. turn oxygen needle valve off.
   c. bleed line by opening acetylene needle valve and back off regulator, then close valve.
   d. open oxygen needle valve, back-off regulator, close needle valve.
   e. close cylinder valve.

9.1.4 Manual and Semi-Automatic Cutting Machines.

A. Operations

1. Metal is heated to red hot (about 1600^{o} F.); a jet of pure oxygen directed at hot area will burn through in a narrow slit called a "kerf."
2. Cutting torch tips are designed to preheat and provide jet of oxygen for burning.
3. Balance between speed of tip movement across the metal, oxygen jet size and intensity of the flame must be achieved to insure a continuous operation.
4. Large amount of cutting is done with manual cutting torches.
5. Greater precision is accomplished when torches are mounted on controlled speed machines.

B. Manual Cutting

1. Two types.
   a. standard cutting torch; used for cutting only.
      (1) has oxygen needle valve and acetylene needle valve, both on rear of torch body.
      (2) use valves to adjust flame to neutral, correct flame for use.
      (3) depress upper oxygen control bar to direct high pressure oxygen to metal for cutting action.

b. combination cutting torch; used for both welding and cutting with same equipment.
   (1) uses welding torch body and cutting attachment.
   (2) cutting attachment is used with welding tip removed.
   (3) installed by use of threaded nut and neoprene seals.
   (4) designed for installation and removal of attachments without use of tools; hand-turn pressure is adequate.

2. Tips for cutting torches.
   a. many tip designs available for special purposes.
      (1) gauging, cutting off rivet heads, heating.

3. Classification of torches by mix.
   a. injector; uses acetylene less than one pound pressure.
   b. balanced pressure; requires from one to fifteen pounds pressure.

C. Semi-Automatic Burning Machine

1. Straight-line cutting machine.
   a. most common.
   b. self-propelled, runs on sections of straight track.
   c. uses standard cutting torch.
   d. adjust for width, raises and lowers, angles and bevels.
   e. can use more than one torch.
   f. use variable speed reversible motors.

2. Shape-cutting machines. a. may use a magnetic spindle and single torch. b. some use electric eye which locks on to line of drawing and cuts with great accuracy. c. magnetic types magnify any irregularity. d. shape-cutters may use from two to eight torches, allowing an equal number of duplications to be cut at one time. e. magnetic spindle type machine requires a pattern; involves more work for operator.	ILS 2008
D. Method: Manual Combination 1. Torch. a. body; handle. b. nut fittings; for hose attachment. c. needle valves; for gas supply. d. welding tip; with nut and neoprene fittings to use with torch body when welding; available in different sizes as determined by tip hole size. 2. Cutting attachment. a. pre-heat valve; adjust cutting flame with oxygen needle valve and acetylene needle valve on body. b. oxygen cutting lever; depress for oxygen stream for cutting. c. tip nut; secures tip to attachment.	ILS W2010

d. tip; cutting tips vary for different uses; oxy-acetylene tips have one hole on orifice for the cutting stream of oxygen and up to six orifices around oxygen orifice for pre-heating flame; to obtain a good quality cut.
   (1) tips must be protected and handled with care; any damage to sealing fits, orifices, or tip end will affect flame performance.
   (2) proper tip size is important; refer to factory recommendations when making selection.
   (3) orifice surface must be kept round in shape, flat, and at 90^{o} to tip axis.
   (4) tips must be kept clean.

3. Operate manual torch.
   a. assemble materials needed.
      (1) cutting torch, welding goggles, striker, gloves, pliers, 6" x 12" steel plate (1/2" thick).
   b. place plate on cutting table, leaving room at edge of table to rest forearm while cutting.
   c. make sure torch needle valves are closed, turn in pressure adjusting regulator screw until proper gas pressure appears on gauge.
   d. check chart of manufacturer for correct gas pressures.

e. open oxygen needle valve on torch body completely and leave it open while in use.

f. open acetylene needle valve about 1/4 turn and light with striker. Continue opening until smoke disappears.

g. open oxygen pre-heat valve (on attachment) slowly until flame is neutral.

h. press oxygen control lever; observe flame for dark oxygen stream readjust to neutral if necessary.

i. hold torch slightly over edge of plate at spot of entry for cut with inner white cone about 1/16" from plate surface.

j. support torch with free hand, using its forearm, resting on table edge, as pivot point and guide.

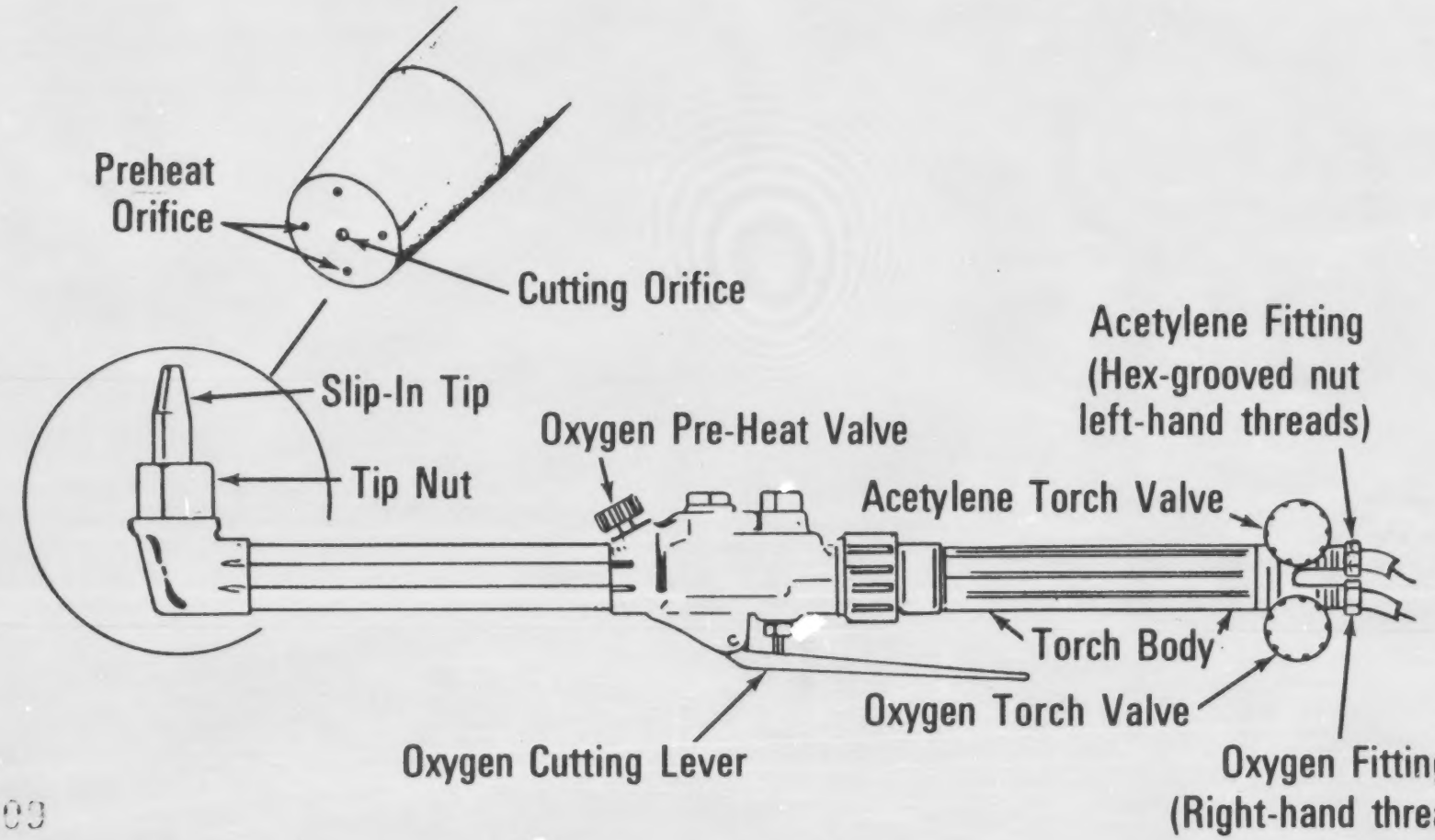
k. when metal shows as red hot, depress oxygen stream lever for cut; a shower of sparks should appear, indicating cutting is taking place. If sparks do not appear, release lever and reheat.

l. as cutting occurs, move torch evenly along cutting line until cut is complete.

m. release oxygen lever immediately upon completion of cut.

n. turn off all needle valves; back off regulator valves and bleed lines.

Parts of a Torch Body and Cutting Attachment



o. handle all hot metal with pliers.

p. remove any adhering slag (oxidized metal) with chipping hammer.

E. Cutting with a Straight-line Cutting Machine

1. Method.

ILS W2009

a. obtain materials needed.

(1) cutting machine, welding goggles, flint striker, slag hammer, gloves, 1/2" plate (about 10" X 18"), set of tip cleaners.

b. identify parts of straight-line cutting machine.

(1) acetylene needle valve.

(2) oxygen needle valve.

(3) high pressure oxygen control.

(4) side adjustment.

(5) elevator knob.

(6) fore and aft tilt adjustment.

(7) in and out adjustment.

(8) travel switch.

(9) on-off switch.

(10) fuse.

(11) speed adjustment.

c. place plate on cutting table.

d. place machine on track, making sure direction switch is in neutral; by hand, run machine to within 2" of starting edge of plate.

e. plug in machine.

f. position torch about one inch above table by turning knurled knob on outside of torch.

g. open acetylene needle valve about 1/4 turn; light torch and continue to open valve until smoking stops; open oxygen needle valve slowly until feather just disappears and inner white cone next to tip is well defined.

h. open oxygen stream control valve and observe flame; adjust to neutral; shut off oxygen stream control valve.

i. push machine to plate edge with center of cutting tip slightly over edge of plate.

j. lower torch until inner white cone is about 1/16" from plate surface.

k. as soon as preheat color becomes bright red, turn on oxygen stream control valve. If no shower of sparks appears, shut off oxygen stream and reheat to higher temperature.

l. with sparks indicating proper cutting temperature and oxygen stream on, flip direction control switch to forward.

m. adjust speed for best cutting speed.

n. after cut is complete, immediately shut off oxygen stream control valve and travel switch.

o. to shut down, turn off needle valves, back off regulators, bleed lines and pull electric plug.

F. Cutting Bevels with Manual Torch

1. Method.

a. assemble required materials.

(1) cutting equipment, welding goggles, pliers, gloves, flint striker, tip cleaners, 6" X 3" piece of 1/2" plate scrap.

b. make sure scrap has at least one straight edge, mark a line 3/4" in from edge and parallel to it.

c. light torch and adjust.

d. assume comfortable position; hold torch toward end of plate and beveled to desired angle (30^{o}); start cut beginning at edge on one end of plate and continue to the other.

e. tip edge can be rested on metal to help steady torch.

f. determine best speed by observing spark shower and listening to sound; should be similar to that of shredding paper.

g. if cutting action stops, preheat a spot just ahead of spot where cutting stopped and restart cut with a slower speed.

h. observe finished cut for indicated problems; handle hot metal with pliers.

i. shut down valves and bleed lines.

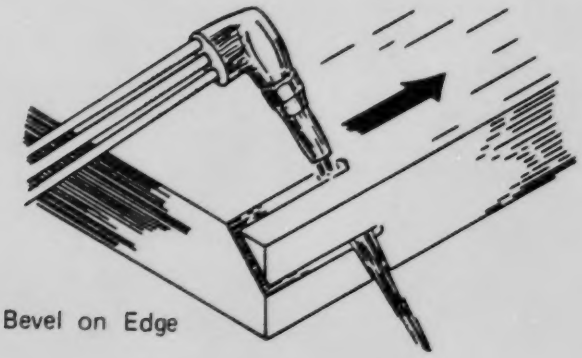
j. clean tip, if necessary.

ILS W2012

JOB SHEET #5

D. Hold torch with both hands at desired angle to metal as shown (Figure 1)

FIGURE 1



Bevel on Edge

E. Hold preheat flame with tip of inner cone (neutral flame) 1/16" to 1/8" above top of plate until bright red spot appears

F. Depress oxygen cutting lever and proceed across plate with very consistent movement being careful to maintain constant tra' el speed, torch angle, and flame to work distance

G. Practice until you develop the proper procedure

H. Turn in exercises for instructor's approval and grading

G. Piercing Holes with Manual Torch

1. Method.

a. assemble materials and equipment.

(1) cutting torch and tip, scrap steel 3/8" to 1/2" thick, soapstone or chalk, gloves, pliers, striker, slag hammer, welding goggles, center punch and hammer.

b. select tip one size larger for cutting than welding.

c. place piece of scrap on cutting table.

d. mark size hole desired using either chalk or soapstone, or, with center punch, place punch marks 1/4" to 1/2" spaced around line (hole may be any shape or size); punch marks are much more visible than chalked line.

e. light torch and adjust flame to neutral; press oxygen bar and readjust.

f. heat a spot in marked area to bright cherry red.

g. press oxygen control lever very slowly, at same time raise torch slowly to about 1/2" above the surface; as cutting action starts, move tip slowly to one side, so as to start a small spiral motion; notice slag is blown out opposite side of puddle; when cut has pierced completely through plate, lower tip to normal cutting height (about 1/4") and continue spiral motion for cutting hole or draw

ILS W2013

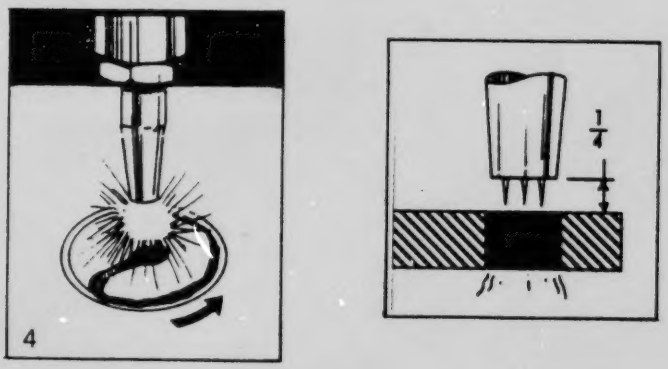
JOB SHEET #6

K. Return cutting torch to vertical position

1. Raise cutting tip until tip of inner cone is from 1/4" to 1/2" above the plate

2. Make cut (Figure 2)

FIGURE 2



L. Cut just inside soapstone mark until circular cut is completed

M. Repeat steps K and L until all holes are cut

N. Cool metal by placing in can of water with the aid of pliers

O. Show samples to instructor for approval and grading

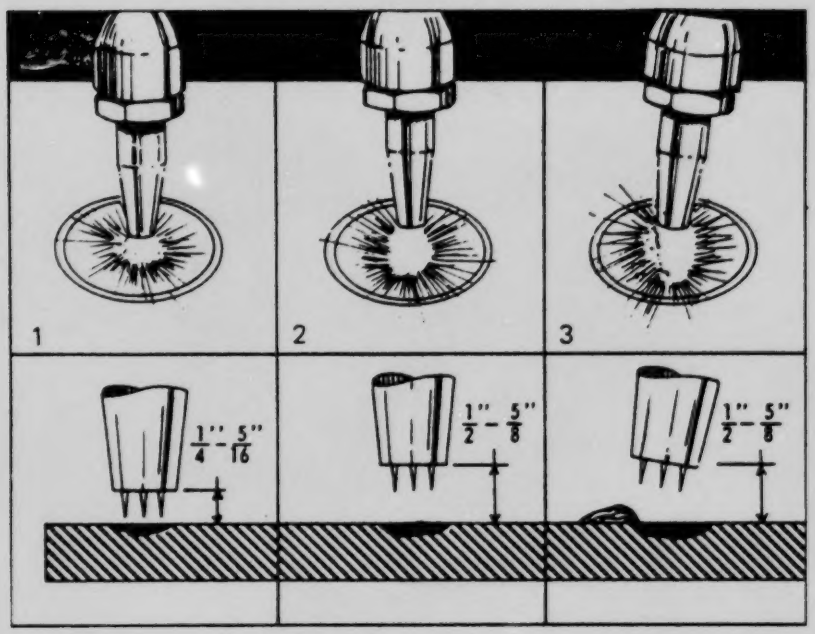
JOB SHEET #6

H. Place hoses behind operator

I. Maneuver torch with both hands

J. Hold tip of inner cone 1/16" to 1/8" above point to be cut until metal turns bright red (Figure 1)

FIGURE 1



1. Tilt torch 15° from vertical position

   (NOTE: This will allow molten metal to be blown away from operator.)

2. Depress oxygen cutting lever slowly moving torch backwards (to the operator's right if right-handed) until cut pierces plate

tip to cutting line and proceed along line at required speed.

h. make sure tip is clean for good cutting.

i. cool metal in water tanks; handle hot metal with pliers.

j. shut down tanks, gauges and valves; bleed lines.

k. hang up torch to prevent damage to tip.

10.0 Welding Processes

INSTRUCTIONAL OUTCOMES: The student will be able to describe and explain the use for various weld joints, describe the processes necessary to weld them, and demonstrate basic skill proficiency in their execution.

INTRODUCTION: A skilled welder is more than a good mechanic; he or she understands the reasons behind choosing a particular process and is able to carry the process out efficiently and professionally.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
10.1 Weld Joints A. Butt Joints 1. Plain butt joint. a. plates of metal up to 3/16" thick butted together without beveling edges. 2. Opened butt joint. a. plates up to 3/16" are spaced 3/32" to 1/8" apart to allow for expansion; joint tacked at both ends to prevent drawing together; backup plate may be used to prevent bottom edge burn-through. 3. Vee joint. a. best for holding power and used for metal thicker than 1/8";	ILS Industrial Mechanics 603F

veeing is beveling with grinder or cutting torch; may be veed on one or both sides.

b. double vee on thick materials saves weld time and materials, less metal is removed; also best on round stock such as rods, axles, shafts.

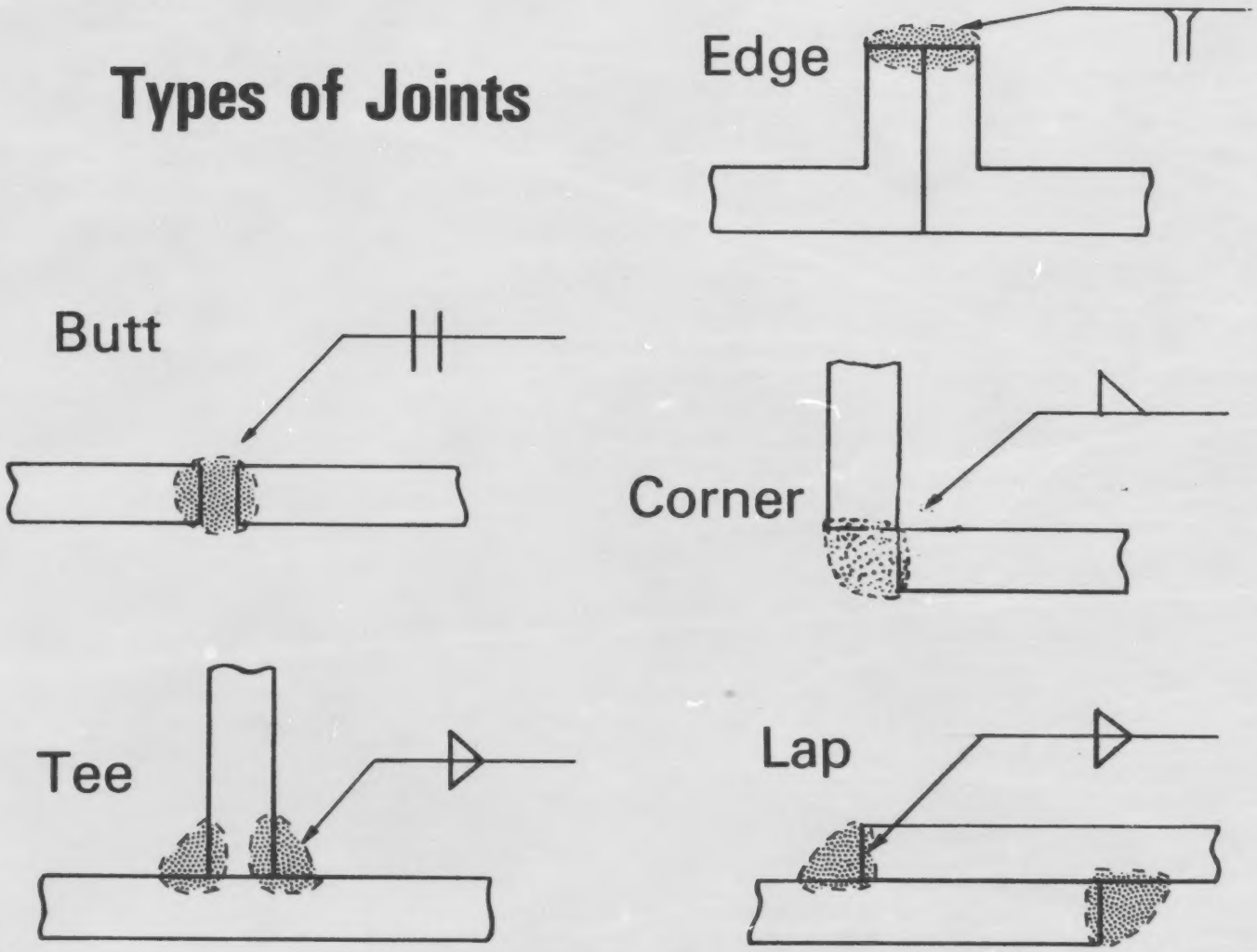
B. Lap Joints

1. Simplest and most frequently used.
2. Made by lapping one part a short distance over the other; amount of overlap depends on thickness of metal and strength required.
3. Joined with a fillet weld across ends of overlapped parts.
4. Weld both sides for greater strength.
5. Tack weld both ends before welding.

C. T-Joints

1. Used widely in construction and repair work.
2. No beveling is necessary.
3. Place metal together at approximate right angles (form a "T").
4. Strength of joint dependent on closeness of fit.
5. Welded both sides to withstand stress from either direction.
6. Tack both ends before welding.

Types of Joints



D. Corner Joint

1. Used mainly in light gage steel and often in rectangular objects requiring smooth corners.
2. Pieces placed at approximate right angles, so edges form a 90^{o} vee on outside.
3. Tack both ends before welding.
4. Light gage metal may be welded with no filler metal or with one bead; heavier metal may require more passes.

E. Flange Joint

1. Simple to contruct, used where two plates come together, as in tank construction.
2. Pieces must be held tightly together with good tacks or clamps.
3. Good penetration required as only outside is welded.

10.2 Puddle Without Rod

A. Method

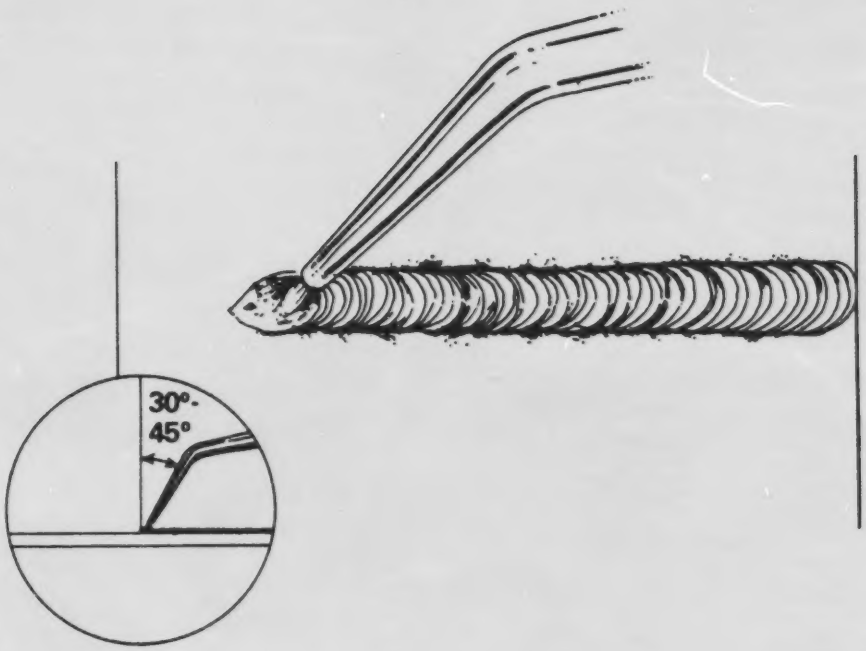
ILS W2101-1

1. Assemble materials.
   a. goggles, gloves, striker, pliers, torch and tip, 14-gage steel, 4" X 6".
2. Set regulators for correct pressure.
3. Lay metal on firebrick.
4. Place goggles over eyes.
5. Light torch and adjust to neutral flame.
6. Hold torch with hoses over outside to wrist; balance torch to avoid fatigue.

7. Hold tip of cone 1/8" above plate; start bead 1/2" from edge with tip pointed in exact direction of weld; angle tip at about 45 degrees to work.
8. Hold flame in one spot until a puddle of metal 1/4" to 5/16" in diameter is formed.
9. Move torch forward at rate to advance molten puddle; if moved too fast, metal will not melt properly, too slow a hole will appear.
10. Bead should be smooth, glossy and even
11. Practice different torch motions.
    a. circular.
    b. zig-zag.
    c. semi-circular.
    d. oscillating.
    e. zipper.
12. A loud snap or pop is backfire.
    a. caused by incorrect pressure, check gauges; loose tip, check tip; dirty tip, clean tip; tip too close to metal, check motion; overheating, tip too close.
13. Loud hiss or squealing noise is a flashback, may (or may not) be accompanied by smoke or sparks from torch, flame goes out.
    a. something wrong with torch or operation.
    b. turn torch off immediately, allow to cool, check operating pressure; before relighting, allow oxygen to flow through torch to help clear soot.

JOB SHEET #4

III. Diagram of the procedure



c. follow usual procedure to relight torch; if normal flame is produced with no squeal, proceed as usual. If squeal recurs, shut down torch and remove from service 14. Follow shutdown procedures and put materials away.	
10.3 Puddle With Rod A. Filler Rod--rod of metal used to add metal in weld area, must have same properties as base metal. 1. Adding rod too quickly will chill puddle and cause low penetration. 2. Adding rod too slowly will cause heat build-up. 3. Puddle can be controlled by amount of metal deposited in puddle in each dipping motion. 4. Use rod with diameter equal to thickness of metal being welded, up to 3/16".	ILS W2101-2
B. Laying Beads with Filler Rod 1. Requires coordination of two hands. a. one hand manipulates torch to carry puddle across plate, other hand dips rod in puddle and adds correct amount of filler rod.	
C. Method 1. Assemble materials. a. welding torch and tip, filler rod, scrap steel 4" X 6", spark lighter, gloves, goggles.	

2. Set regulators to correct pressure.
3. Place metal on firebrick.
4. Light torch and adjust to neutral flame.
5. Hold torch in balanced position to avoid fatigue.
6. Hold tip of flame cone 1/8" above plate; start bead at end of metal, point tip in direction of weld, maintain tip angle of 45^{o} to work.
7. When puddle is formed, add filler rod to front edge of puddle in front of torch.
8. Move puddle forward with torch and allow puddle to form in base metal.
9. Add rod and withdraw to front edge of puddle as puddle is moved forward.
10. Hold rod at 45^{o} angle and allow rod to melt into puddle; do not melt off rod with torch.
11. Repeat, moving puddle and dipping and withdrawing rod in even rhythm; material will build up, buildup is called a bead.
12. If rod is placed anywhere except the center of puddle it will stick (freeze); melt it loose, do not break it off.

10.4 Forehand and Backhand

A. Forehand Welding

1. Called ripple welding.
2. Recommended for material up to 1/8" thickness for better control.

ILS Industrial Mechanics 602-N

3. Welding rod moves ahead of torch tip in direction in which weld is being made.
   a. flame is pointed in same direction
   b. welding rod and tip are manipulated to give opposite back and forth movements in semi-circular paths; motion provides uniform distribution of both heat and molten metal along path of weld.
4. Disadvantages; for thick metal, a very wide vee is required and the beveled edges of the vee have to be deeply melted to provide good fusion of base metal.

B. Backhand Welding
1. Recommended for thicker metal.
2. Torch flame pointed back at molten puddle.
3. Motion of rod may be oscillating, end of rod moving from side to side in puddles; motion of rod may be full circle within puddle, back and forth across puddle or in semi-circles part way around puddle and back.
4. Torch is held so flame is moved back and forth across weld to form metal into, and up, each side wall.
5. Advantages; narrow vees, 60^{o} often sufficient.
   a. less puddling required; means savings in time, gas and material.

C. Method

1. Assemble materials.
   a. goggles gloves, pliers, striker, scrap metal 1/8" X 4" X 6", welding torch and tip #2 or #3, welding rod 1/8", soapstone.
2. Mark lines 1" apart across metal.
3. Check regulators and torch for proper settings.
4. Light torch and adjust to neutral flame.
5. Run forehand bead.
   a. preheat metal near edge until puddled; hold rod near flame so that it preheats also.
   b. start semi-circular (or your choice) motion with torch about 1/2" wide.
   c. move rod in and out of flame, leaving rod in flame just long enough to melt rod into puddle.
   d. movements give pattern to weld bead; faster the movement, smaller the bead and less rod is used; slower the movements, wider bead and more penetration.
   e. if puddle near torch appears white in color, remove heat and let cool for a few seconds, restart.
   f. cool metal in water, holding with pliers, before starting next bead.
6. Run backhand bead where torch tip is ahead of rod in direction of welding; use same procedures and motion.

10.5 Weld Corner Weld Without Rod

A. Process

1. Assemble materials. ILS W2106
   a. torch and tip as recommended, two pieces 14-gage sheet metal 1 1/2" X 5", goggles, pliers, gloves.
2. Weld can only be made on light-gage steel; thicker steel needs more metal or is seriously weakened.
3. Set regulators to recommended pressure.
4. Position two pieces of metal in a tent position with apex at top (A frame).
5. Light torch and adjust to neutral flame.
6. Tack pieces at ends and at 2" intervals.
7. Direct flame at about 45^{0} angle with joint and in direction of travel.
8. Form puddle with both pieces joined, using enough motion to melt outer edges, move along the seam; move slowly enough to assure some penetration, but not slowly enough to burn through.

10.6 Butt Weld Flat Position

A. Process ILS W2104

1. Assemble material.
   a. oxy-acetylene welding unit, filler rod, goggles, striker, pliers, gloves (if necessary), two pieces 14-gage steel 1 1/2" X 6".

2. Plain butt weld.
   a. set recommended pressure on regulator.
   b. place sheets of metal side by side on fire brick.
   c. light torch, adjust to neutral flame.
   d. tack each end and at 2-inch intervals and weld.
3. Open butt weld.
   a. place sheets side by side and space 1/16" apart at one end and 1/8" apart at other end.
   b. light torch; adjust to neutral flame.
   c. tack weld at 2-inch intervals and weld.
4. Progressive butt weld.
   a. tacking not required, place pieces across two bricks with one end touching each other and other end spaced 3/16" apart.
5. Any butt weld.
   a. hold tip of cone 1/8" above seam; point tip in direction weld will move; hold tip at about 45^{o} to work.
   b. allow puddle to form and move torch in small circles until puddle is about 5/16", diameter and is melting through; completed weld should show some penetration on bottom.
   c. add filler metal to puddle.

10.7 Flange Weld

A. Method

ILS W2103

1. Assemble material and equipment.
   a. oxy-acetylene welding unit, filler rod, welding goggles, striker, pliers, gloves if necessary, two pieces light gauge steel 1 1/2" X 6".
2. Turn up one edge of each piece by placing in a vice so 1/8" protrudes above vise jaws, hammer protruding edge down flat to make flange edges a 90^{o} bend.
3. Check manufacturer's chart for correct tip size and regulator pressures, select tip.
4. Set regulator pressures.
5. Place metal pieces on table with flanged edges touching.
6. Hold two flanged edges together with pliers and tack at 1-inch intervals.
7. To weld, hold flame steady until two edges become molten; move forward with side to side motion, fusing two pieces together; flange will serve as filler metal.

10.8 Lap Joint Fillet Weld

A. Method

ILS W2105

1. Assemble material and equipment.
   a. oxy-acetylene welding unit, welding (filler) rod, goggles, spark lighter, pliers, hammer, three pieces light gauge steel 1 1/2" X 6".

2. Select tip and regulator pressure from manufacturer's chart and set regulators to correct pressure.
3. Place two pieces of metal flat on fire brick (as though making butt weld); place another piece on top of two, half on each piece; should leave overlap of 3/4".
4. Tack weld at both ends with no gap between; only two pieces should be tacked together, third (bottom) piece is support for top piece; if gap exists between two tacked pieces, hammer them closed.
5. Less heat is required to melt edge of top piece than lower, direct more of flame onto lower piece; point tip at 45^{0} angle in direction of travel.
6. Dip welding rod at top of molten puddle; protects top edge from burning away.
7. Welded portion (bead) must be at least as thick as lapped piece being welded to insure full strength; add enough rod material to crown weld slightly.
8. Turn over and weld other side.

10.9 "T" Joint

A. Method

1. Assemble material and equipment.
   a. oxy-acetylene equipment, striker, goggles, pliers, filler rod, two pieces metal 1/8" X 2' X 6".

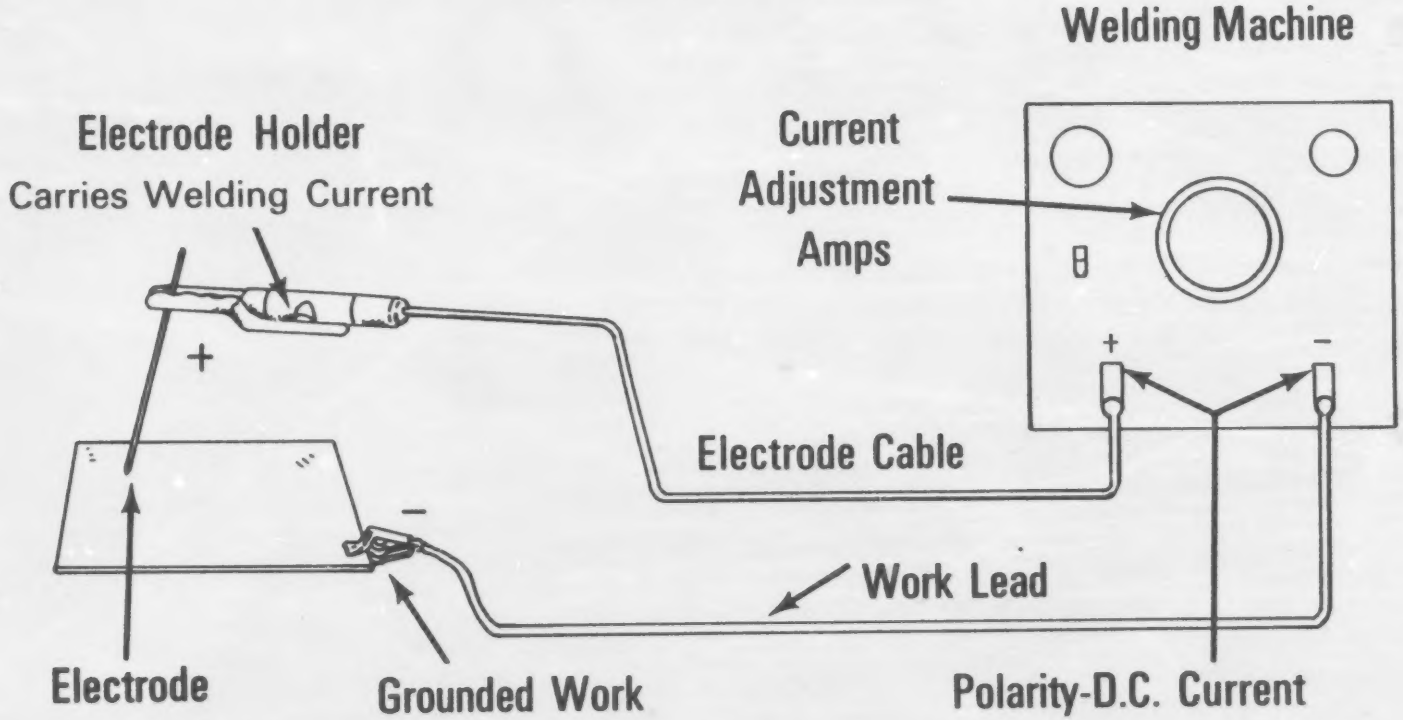
ILS Industrial Mechanics 602-J

2. "T" joint is made by placing two parts together at approximate right angle to each other; joined by fillet weld along line where two plates meet
3. Hold torch so that tip forms an angle of 45^{o} to the flat plate and same angle of roughly 30 degrees to line of weld and 15 to 10 degrees to horizontal plate.
4. Direct flame more toward bottom plate keeping inner cone of flame about 1/8" from surface; prevents undercutting vertical plate; keep puddle moving and add rod to vertical side of puddle.
5. When weld is complete, should show good bead, good fusion, consistent width of bead, clean appearance, equal distribution of metal, half on vertical, half on horizontal surface.
6. Processes.
   a. tack both ends.
   b. adjust flame for a slight amount of excess oxygen.
   c. use weaving motion to keep both plates at welding temperature.
   d. when reaching end of weld, raise flame to allow puddle to cool slightly before finishing weld.

10.10 Electric Arc Welding--(SMAW)--Stick Welding

A. Shielded Metal Arc Welding

Welding Circuit



Electrode

Diameters:
1/16 - 5/16 x 14'
Most Common
Length

Grounded Work

Completes
Welding Circuit

Reverse:

1. Electrode (+)
2. Current flows from work to electrode
3. 2/3 heat at (+) electrode
   1/3 heat at (-) work

Straight:

1. Electrode (-)
2. Current flows from electrode to work
3. 2/3 heat at (-) work
   1/3 heat at (+) electrode

1. An arc welding process wherein metals are united by heating with an electric arc between a coated metal electrode and the metal.

B. Definitions

1. Arc--the flow of electric current from the tip of the electrode to the base of the metal being welded.
2. Electrode--metal rods which conduct a current from the electrode holder to the base metal.
3. Base metal--the metal to be welded.
4. Arc length--distance from the end of electrode to point where arc contacts work surface.
5. Crater--a depression at end of weld.
6. Face of weld--exposed surface of a weld on side from which welding was done.
7. Flux--a fusible material or gas used to dissolve and/or prevent the formation of undesirable inclusions formed in welding.
8. Pass--a single longitudinal progression of welding operation along a joint.
9. Porosity--gas pockets or voids in metal.
10. Spatter--the metal particles given off during welding which do not form part of weld.
11. Undercut--a groove melted into the base metal adjacent to toe of weld and left unfilled by weld metal.

12. Weaving--a technique of depositing weld metal in which the electrode is oscillated.
13. Weld metal--portion of weld which was melted.
14. Whipping--term applied to an inward and upward movement of electrode employed in vertical welding.

C. Arc Welding Equipment
1. Welding machines.
a. AC--(alternating current).
(1) current changes direction 120 times per second.
(2) AC transformers produce only AC current; considered to be least expensive, lightest, smallest machine, low operating cost, low maintenance, free from arc blow.
b. DC welding machine (direct current).
(1) motor generators; designed to produce current in either straight or reverse polarity; switch for desired current on machine.
(2) Rectifier; transformers, containing a device which changes AC into DC; some are designed to produce both AC and DC in reverse and straight polarities; rectifier is considered more efficient than motor generator;

current control is achieved by a switching arrangement where one switch is set for desired current range and a second dial for securing fine adjustments required.

2. Helmets and hand shield; protects skin and eyes from invisible, harmful ultraviolet and infrared rays.
   a. helmet.
      (1) fits over head.
      (2) can be swung upwards or lens opened when not welding.
      (3) leaves both hands free.
   b. hand shield.
      (1) same protection as helmet but must be held in place with hand.
   c. lens; special color which screen out harmful rays.
      (1) shade #8--arc weld from 30 to 75 amps.
      (2) shade #10--arc weld from 75 to 200 amps.
      (3) shade #12--arc weld from 200 to 400 amps.
      (4) shade #14--arc weld over 400 amps.
   d. lens cover; inexpensive clear glass or plastic, fits over shaded lens and protects it from spatter.

3. Goggles; clear lens eye protection, must be worn to protect eyes from chipped slag; included in some helmets. 4. Gloves; leather gauntlets protect hands and skin from spatter and rays. 5. Apron; protects skin and clothes from hot metal spatter; usually of leather, may be only an apron or cover entire person, depending on requirements and preference. 6. Chipping hammers, hand held hammer with dull edge for slag removal. 7. Wire brush; long-handled wire brush used for slag clean up; brush may be combined with chipping hammer. 8. Cables; carry current to and from work; one cable attached to work or workbench; one runs from electrode holder to machine; cable attached to work or bench is called ground cable. 9. Electrode holder; a handle-like tool attached to cable, designed to hold electrode in several positions; well insulated.	
10.11 Select Current A. Information 1. Welding machines produce three different types of current, each of which produces different depths of weld penetration. It is important to select right welding electrode and welding current for specific job. The three different currents are:	ILS Industrial Mechanics 603-C Welding Currents

a. alternating current (AC).
b. direct current straight polarity (DCSP).
c. direct current reverse polarity (DCRP).

2. Alternating Current (AC)
   a. easiest for beginners as there is no "arc blow".
   b. has more spatter, but not prohibitive.
   c. cannot run any special electrodes
   d. depends on 220 power, is not portable.
   e. current flows first in one direction, then the opposite, changing 120 times a second; polarity of the electrode changes with each change in current.
   f. electrodes must be used that operate well on either straight or reverse polarity; check electrode chart.
   g. correct amperage setting in relation to metal thickness and diameter of rod will produce a weld with medium to deep penetration.
3. Direct current straight polarity (DCSP).
   a. gives minimum penetration of rod metal into the base metal.
   b. use of E 6012 rod with DCSP for root pass is recommended where poor fitup is present.
   c. combination is also excellent on thin metal.

10.12 Select Electrode

A. Information

1. Electrode also called rod or stick.
2. Coated metal wire having approximately same composition as metal to be welded.
3. When transformer produces a current and it flows through circuit to electrode, an arc is formed between end of electrode and work; arc melts electrode and base metal; melted rod flows into molten coater and forms a bond between two pieces of metal being joined.
4. Practically all electrodes have heavy coatings of various substances which, when melted, serve as/to
   a. cleanser and deoxidizing agent in molten crater.
   b. release inert gas to protect molten metal (shield).
   c. form protective slag which protects weld from air and slows down rate.
   d. provide easier arc start, stabilize arc and reduces spatter.
   e. permits better penetration.
   f. adds some materials to weld metal composition.
5. American Welding Society (AWS) has developed series of indentifying number classifications and color codes. Each type of electrode assigned a specific symbol, each symbol has specific meaning.

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a. example--E-6010
   E = electric welding
   60 = 60000 lbs. tensile strength
   1 = welding position used (1 = all positions)
   0 = power supply, type of covering, type of arc.

b. meaning of symbols;
   E = always denote "electric welding"; first two digits stand for pounds per square inch (psi); tensile strength may run up to 120 psi by tens. Third digit indicates possible welding positions. Three numbers are used:
   (1) for all positions
   (2) for flat or horizontal
   (3) for flat position only.
   The forth digit shows the weld quality, type of arc, amount of penetration and power supply. The numbers may be 0 to 6:
   0--DC with reverse polarity, high quality deposits with deep penetration, flat or concave beads.
   1--AC or DC with reverse polarity, high quality deposits, deep penetration, flat to slightly concave beads.
   2--DC with straight polarity only, medium arc, medium quality deposits, medium penetration, convex beads.

3--AC or DC current with either polarity, medium to high quality deposits, soft arc, shallow penetration, and slight convex beads.

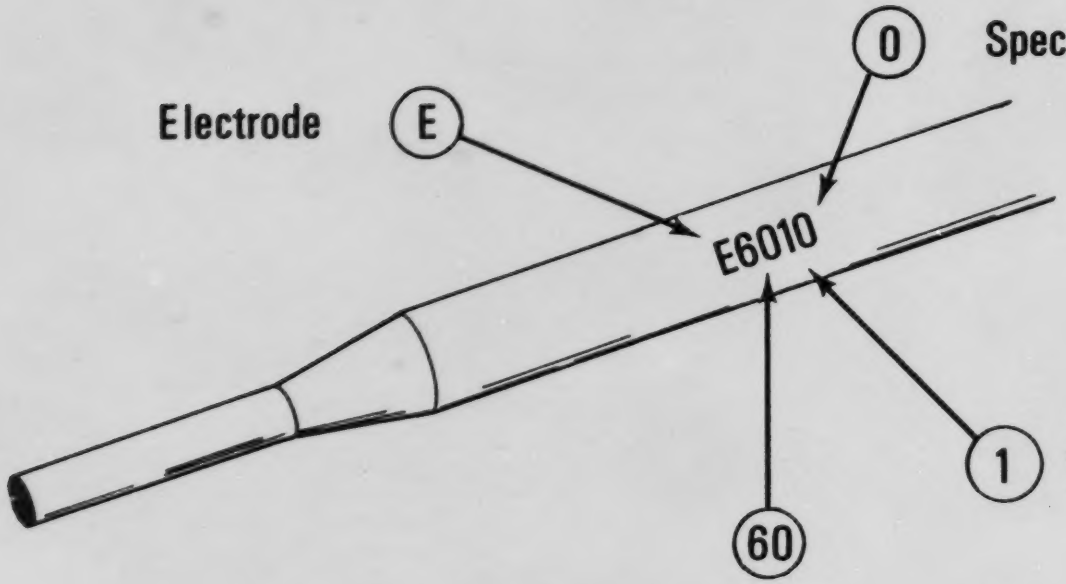
4--AC or DC positive, fast deposit rate, deep groove butt, fillets and lap welds, medium penetration, easy slag removal.

5--DC with reverse polarity, high quality deposits, soft arc, moderate penetration, flat to slightly convex bead, low hydration content in weld deposits.

6--AC with same qualities as number 5.

6. To determine which electrode should be used, determine properties or type of metal being welded, refer to any table of electrodes for that type; manufacturers issue reference guide, charts and tables; provide
   a. AWS number or color code.
   b. weld bead discription.
   c. chemical analysis of electrode.
   d. mechanical properties.
      (1) tensile strength.
      (2) yield point.
      (3) expansion--elongation.
      (4) contraction--reduction.
   e. type of current and amperages.
   f. recommended welding procedures.

Standardized AWS Classification



0 Special Characteristics

current
penetration
type of flux
coating

1 Welding Positions

1. all positions
2. flat and horizontal

Tensile Strength 1,000 Lbs. Per Sq. Inch

E6010 Mild Steel Electrode

WELDING CHARACTERISTICS AND OPERATING DATA OF MILD STEEL ELECTRODES

	Coating Color	Position of Welding	Type of Current* Used	Penetration	Rate of Deposition	Appearance of Bead	Minimum Tensile Strength	3/32" Size	1/8" Size	5/32" Size	3/16" Size
E6010	White	All Positions	DC, Reverse (+)	Deep	Av. Rate	Rippled and Flat	62,000psi		75-130	90-175	140-225
E6011	White	All Positions	AC DC, Reverse (+)	Deep	Av. Rate	Rippled and Flat	62,000psi		75-120 70-110	90-160 80-145	120-200 110-180
E6012	Tan	All Positions	DC, Str AC (-)	Medium	Good Rate	Smooth and Convex	67,000psi	55-80 60-90	80-135 90-150	110-180 120-200	155-250 170-275
E6013	Dark Tan	All Positions	AC DC, Str. (-) or Reverse	Mild	Good Rate	Smooth, Flat and Convex	67,000psi	65-100 60-90	90-140 80-125	140-200 125-180	200-260 180-235
E7014	Gray-Br	All Positions	AC DC, Str. (-) or Reverse	Medium	High Rate	Smooth, Flat and Convex	70,000		110-160 100-145	150-225 1350200	200-280 180-250
E7016		All Positions	AC DC, Reverse (+)	Mild to Medium	Good Rate	Smooth and Convex	70,000	70-100	80-130	120-170	170-250
E7024	Dark Gray	Flat Hor. Fillets	AC, DC Straight or Reverse	Mild	Very High Rate	Smooth and Slightly Cvx	72,000	65-120 60-110	115-175 100-160	180-240 160-215	240-300 220-280
E6027	Red Brown	Flat Hor. Fillets	Flat-DC,AC Hor. Fillet DC Str. AC	Medium	Very High Rate	Flat to Concave	62,000psi			190-240 175-215	250-300 230-270
E7018	Gray	All Positions	AC DC, Reverse (+)	Mild	High Rate	Smooth, Flat to Convex	72,000	70-100 80-120	90-150 110-170	120-190 135-225	170-280 200-300
E7028	Gray-Br	Flat Hor. Fillets	AC DC, Reverse (+)	Mild	Very High Rate	Smooth and Slightly Cvx	72,000			180-270 170-240	240-330 210-300

*DC Reverse means DC, reverse polarity (electrode positive).
DC Straight means DC, straight polarity (electrode negative).

7. To select rod, locate AWS number on rod or look for NEMA color code marking.	
10.13 Striking an Arc A. Information 1. Electric arc. a. basic of arc welding. b. maintained as current is forced across a gap between electrode tip and base metal. c. establishing arc is called "striking an arc" and must be done quickly and easily by welder. d. two methods are generally used. (1) scratching. (2) tapping. 2. Scratching. a. easier for beginners and when using an AC machine. b. electrode is moved across metal and scratched on surface like a match. (1) as electrode scratches metal, an arc is struck. c. raise tip of electrode about 1/4" at end of stroke to preheat base metal; prevents shorting, freezing electrode, establishes crater, eliminates excess filler metal build-up, ties in previous bead and insures fusion. d. after arc is established, move electrode back to beginning of line or edge of plate.	ILS 603-B Illustrations Fig. 1 and 2

e. hold rod about 1/8" or thickness of electrode (minus flux) above plate to weld.

3. Tapping methods.
   a. electrode is moved downward to base metal in a vertical position and tapped sharply on metal; as soon as it touches metal, withdraw momentarily to establish arc.
   b. after arc is established, lower arc to about 1/8" or thickness of bare rod to continue weld.
4. To free rod if "freezes" to metal.
   a. keep hood over face.
   b. twist holder back and forth, pulling at same time until rod breaks loose.
   c. if rod does not loosen, release rod from holder.
5. Common difficulties in "striking arc"
   a. a chipped electrode; use a fast scratching motion and hold a long arc.
   b. ground clamp not making good contact; usual sign is clamp sparks; grind down metal for good contact and reclamp.
   c. poor contact in holder jaws, caused by foriegn material, electrode coating or weak spring.
   d. incorrect polarity setting for rod.

6. Method.
   a. assemble materials.
      (1) welding setup, 1/8" E-6010 electrode, 1/4" scrap plate.
   b. clean metal with brush or grinder.
   c. place metal flat on work table.
   d. attach ground clamp securely to table.
   e. set amperage at 100-110, DC electrode positive.
   f. put on helmet and gloves.
   g. clamp electrode bare end in holder 90^{0} to jaws.
   h. turn welder on.
   i. assume natural, steady position, sitting if possible or leaning to steady electrode; put electrode cable over shoulder to reduce fatigue.
   j. hold electrode above plate and move it down until just over plate; hold in vertical position and at 5 to 25 degrees in direction of travel.
   k. lower helmet.
   l. strike arc using scratch method.
   m. withdraw electrode to form excessively long arc to about 1/4"; hold for a second or two to preheat and lower to about 1/8" to start bead.
   n. break off arc by lifting rod.

10.14 Run Bead Using Arc Welder.

A. Bead; a continuous deposit of weld metal formed by electric arc on surface of base metal; proper penetration of good bead requires:

1. Correct electrode; must include consideration of base metal, diameter of rod, type of joint, current value.
2. Correct arc length; if arc is too long, metal melts in large drops side by side as arc wavers, producing wide, spattered, irregular bead with little penetration; arc too short fails to generate enough heat to melt base metal properly and electrode may stick.
3. Correct current; current too high, electrode melts too fast with molten pool too large and irregular; current too low not enough heat, with molten pool too small.
4. Correct travel speed; speed too fast, puddle won't last long enough and impurities are locked in weld; bead is narrow and ripples pointed; speed too slow, metal builds up excessively; bead is high and wide with straight ripples.

B. Crater; Pool Formed When Arc Contacts Base Metal.

1. Size and depth of crater indicates amound of penetration; depth should be 1/3 to 1/2 thickness of bead; arc too long, insufficient spread of heat;

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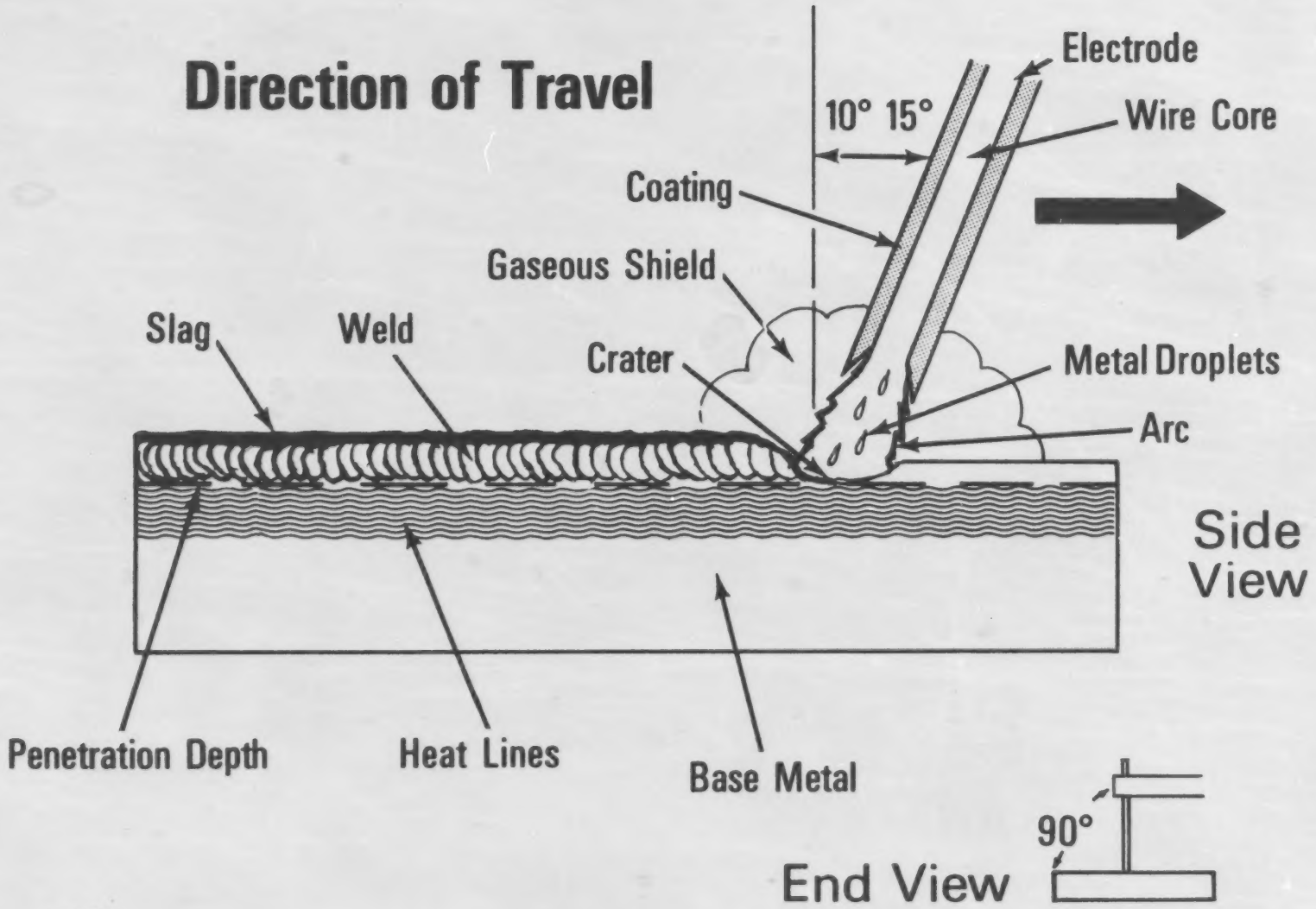

Direction of Travel
Electrode
10° 15°
Wire Core
Coating
Gaseous Shield
Slag
Weld
Crater
Metal Droplets
Arc
Side View
Penetration Depth
Heat Lines
Base Metal
90°
End View

arc too short, heat not intense or centralized enough.

2. Crater too hot; metal has tendency to run; lift electrode and move from side to side ahead of crater, allow crater to cool.
3. Undercutting; current too high; leaves groove in base metal along sides of bead.
4. Overlapping; current too high, molten metal does not really fuse with base metal.

C. Running the Bead

1. Lean electrode in direction of travel and lower as it burns off (to keep constant correct arc length); direct arc back into crater and force molten weld metal to rear edge; slag will wash through weld metal, remove impurities, collect on top of weld, forming heavy, even coat to protect weld while cooling.
2. To avoid deep crater at end of head, hold rod in one place long enough to fill crater, then lift straight up.
3. Make beads in one continuous operation without stopping if possible; to restart bead
   a. remove slag from crater and a short section of bead (about 1/2" of bead). Wire brush clean.
   b. strike arc about 1/2" ahead of crater and move electrode slowly back through crater to the near edge; hold rod there until puddle

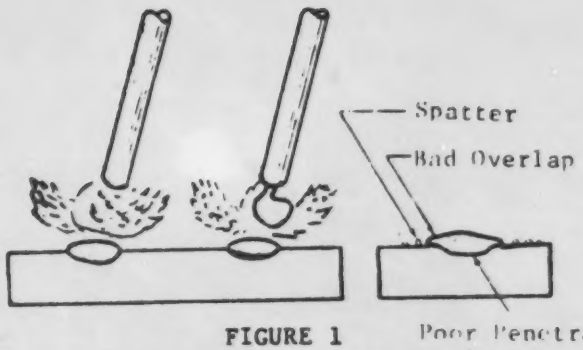


FIGURE 1
A long arc does not protect the molten metal from the air. The weld is poorly fused, spattered, and overlapped at the edges.

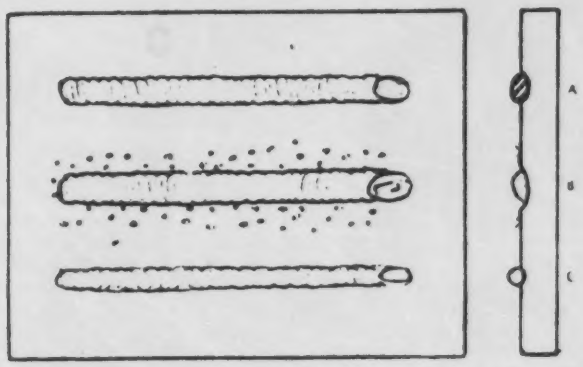


FIGURE 2
The effect of current adjustment.
A-current adjustment correct
B-current adjustment too high.
C-current adjustment too low

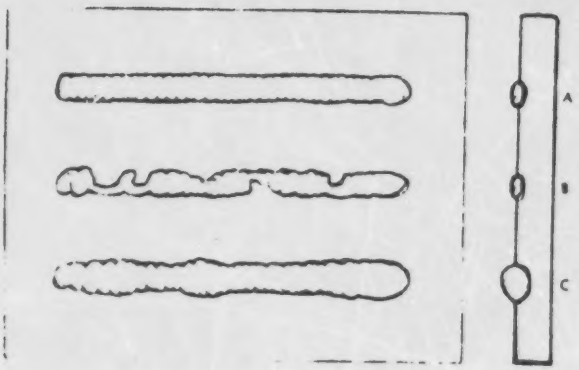


FIGURE 3
Speed of welding.
A-correct speed of welding.
B-speed of welding too fast.
C-speed of welding too slow.

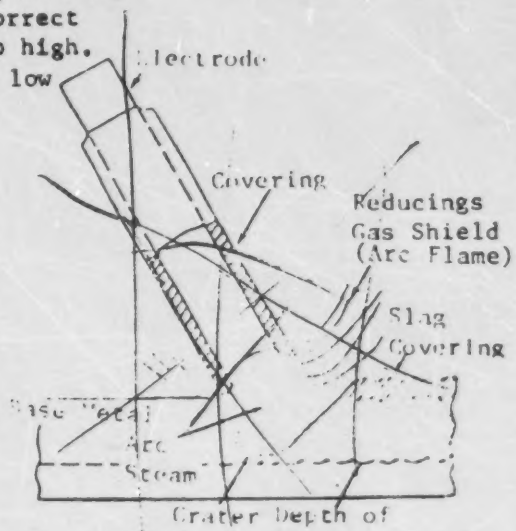
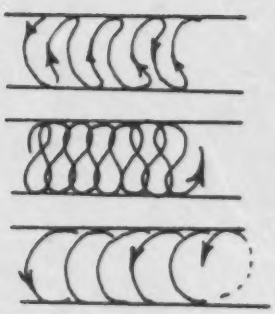
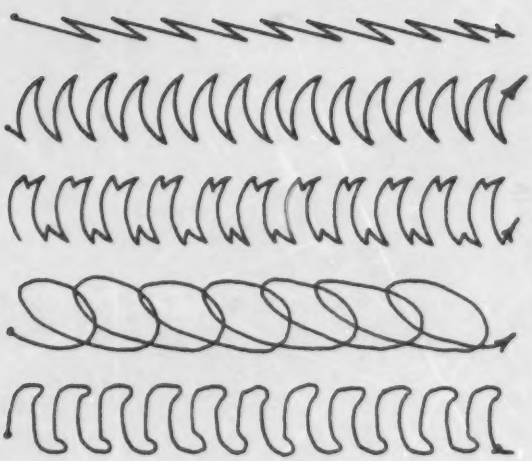


FIGURE 4
A covered electrode arc weld in progress.





is remelted, move forward slowly through puddle and complete bead.

4. During a weld:
   a. observe appearance of bead and arc.
   b. keep eye on back of crater as arc forces deposits and bead build-up.
   c. vary arc length, electrode angle or speed of travel to correct poor bead.
   d. listen for sound; arc at correct length sounds like the sizzle of bacon frying without pops or snaps.
5. Basic methods of running beads:
   a. straight bead; rod in vertical position, about 15^{o} in direction of travel; held as steady as possible and not weaved; most common.
   b. in and out bead; same as straight except rod is held in crater a couple of seconds, then moved ahead for a second, allowing crater to cool, and then brought back to crater again, with same process repeated for entire weld; usually used on thin metal or veed joints and for vertical up welds.
   c. weave weld; used to increase width and volume of bead; used for deep grooves or fillet welds where a number of passes is required; pattern of weave is welder's choice.

D. Method

1. Assemble materials and tools.
   a. arc welder and rod holder, helmet, gloves, pliers, chipping hammer, wire brush, E-6010 electrodes, 1/8" mild steel plate one piece 3/8" thick 6" X 6".
2. Set welding machine DCRP (+) at electrode 75-130 amps.
3. Clean metal plate and place flat on work table.
4. Put on helmet and gloves.
5. Check that ground cable is securely attached to table.
6. Clamp rod in rod holder at 90^{0} to jaws.
7. Turn on welder.
8. Place electrode near plate in vertical position, 15^{0} incline in direction of travel.
9. Lower helmet.
10. Strike arc and move arc end of rod near edge of plate and run bead length of plate.
11. Hang holder up; do not allow rod end to touch work table or arc flash will occur.
12. Let plate cool slightly, then remove slag with chipping hammer and brush it clean; hold hot metal with pliers.
13. Reverse travel direction and run additional beads in same manner, but overlap each additional bead at least 1/3 over previous bead.

14. Clean each pass or bead thoroughly before overlapping with another.

10.15 Flat Position Arc Welding

A. Information

1. Easiest for welding and has advantages over other positions.
   a. increased speed.
   b. better penetration.
   c. molten metal has less tendency to run.
2. Gap; distance from base metal to bottom of rod; should be the thickness of rod above plate; for 1/4" thick rod, use 1/4 inch gap; sound of correct arc is hiss or frying sound.
3. Amount of current; depends on thickness of metal and rod size; check chart.
   a. marking a line with soapstone or chalk will help guide for straight weld.
4. Be comfortable; drape cable over shoulder or around arm to reduce wrist and hand fatigue; sit if possible, lean, if not.
5. After completing bead, let it cool for a minute before chipping off slag and wire brushing.

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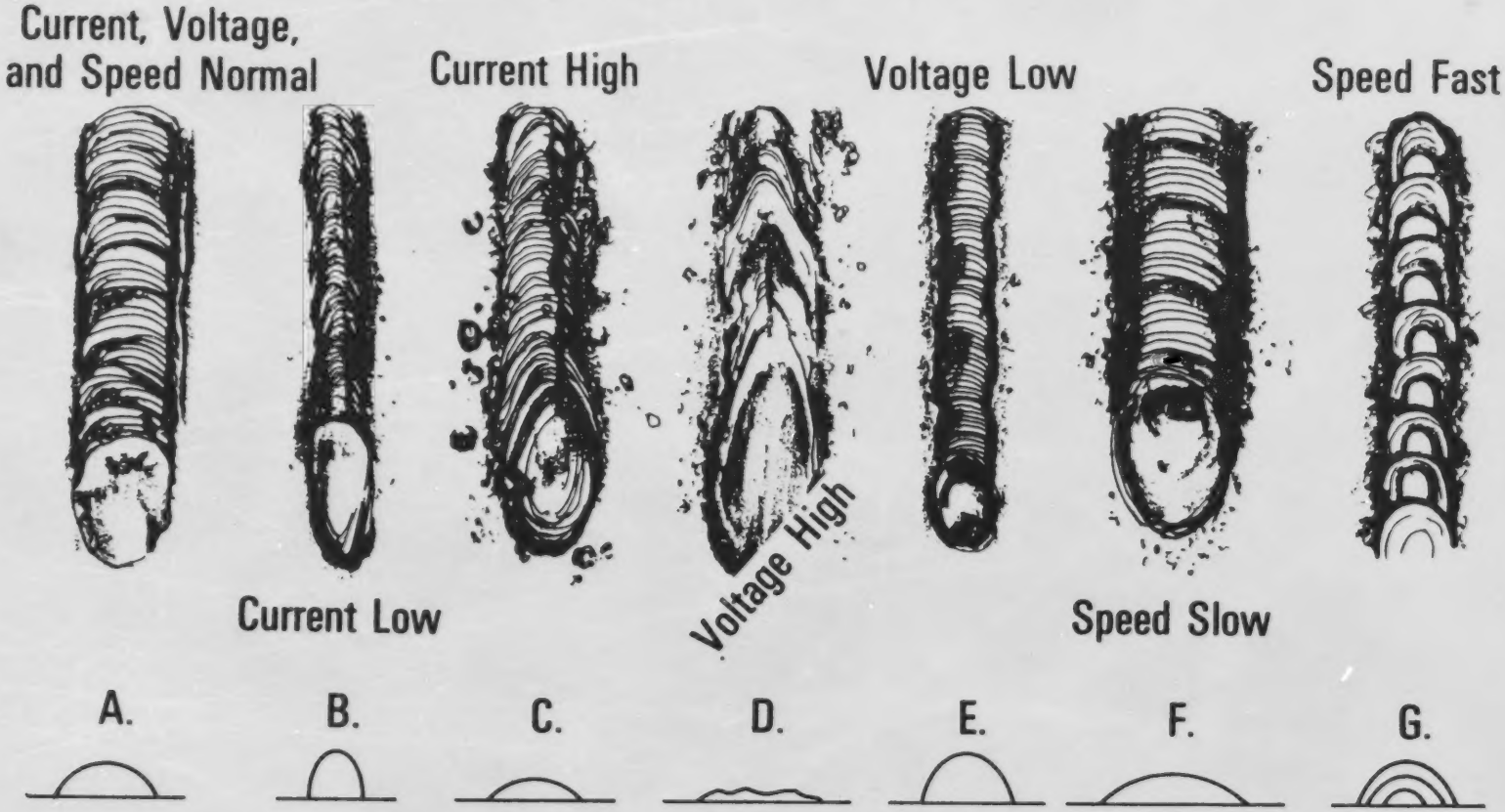
6. Inspect bead for
   a. alignment.
   b. width of bead.
   c. gas pocket.
   d. spatter.
   e. even bead; a good bead will be clean and have shiny surface, even width, good penetration, good fusion.
7. Poor weld factors.
   a. overlap caused by arc moved too slowly or insufficient heat, too short an arc.
   b. gas pockets and impurities; caused by too long arc or arc moved too rapidly.
   c. check for
      (1) unclean metal.
      (2) moisture in rod.
      (3) wrong rod.
      (4) wrong amperage.
      (5) bad ground.
      (6) wrong polarity.
      (7) wrong voltage.

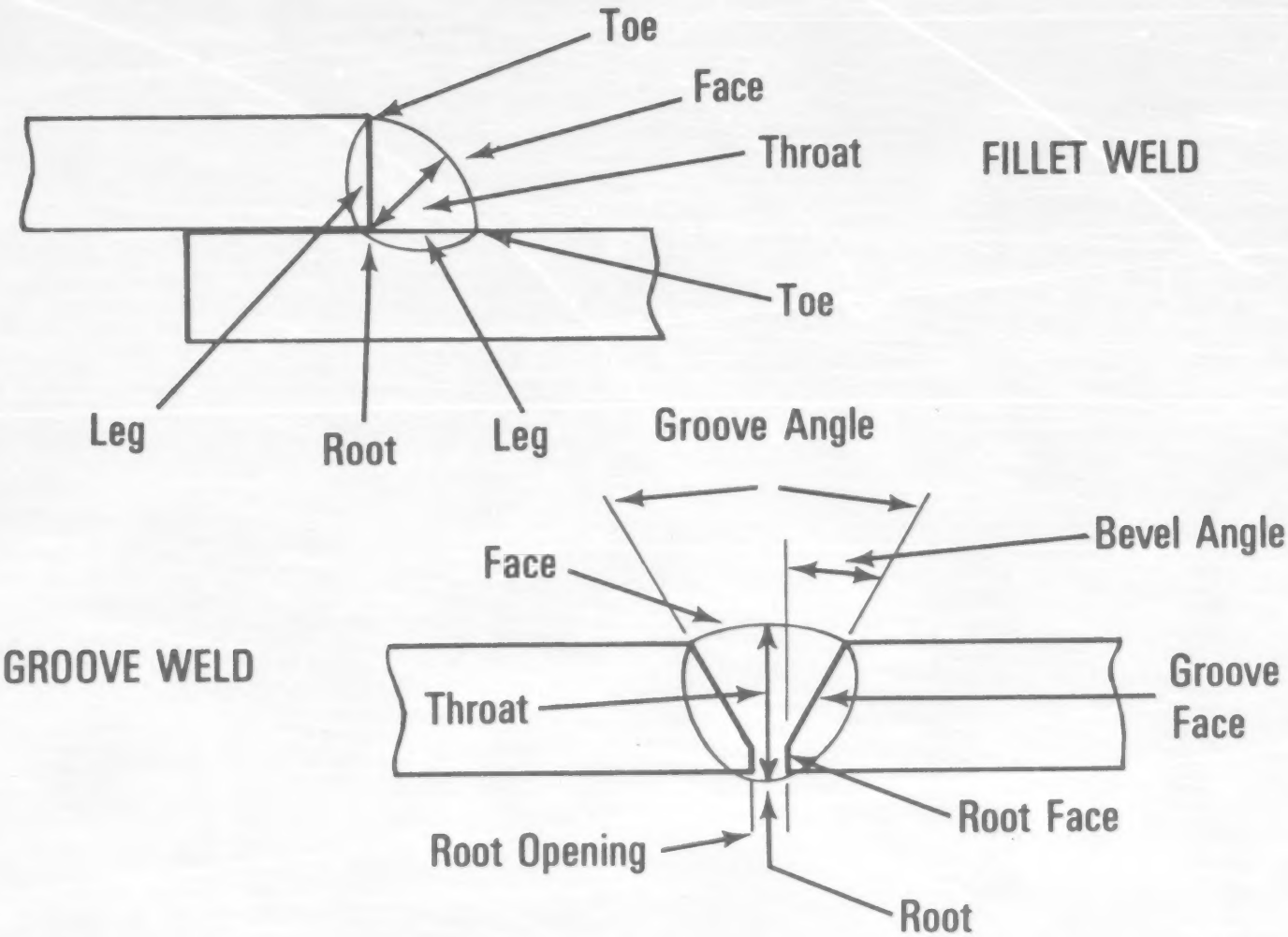
B. Method
1. Assemble materials.
   a. arc welding equipment, helmet, gloves, chipping hammer, wire brush, 1/4" mild steel plate, 1/4" E-6010 rods, pliers.
2. Clean metal and place flat on table.
3. Set current DCRP with 75 to 100 amps.
4. Place electrode in holder.
5. Put on gloves and helmet.
6. Turn on machine.

Properly and Improperly Formed Beads



7. Strike arc and run beads. 8. Hang up holder. 9. Turn off machine. 10. Chip off slag and clean with wire brush. 11. Inspect welds.	
10.16 Flat Butt Vee Weld A. Method 1. Assemble equipment and material. a. arc welder and electrode holder, helmet, gloves, pliers, wire brush, chipping hammer, two pieces mild steel 3" X 6" 3/8" thick, E-6010 electrodes 1/8". 2. Adjust machine for DCRP (+) with 75 to 100 amps. 3. Prepare metal. a. bevel one edge each piece at 30^{o}. b. grind 1/8" root face. c. remove burns and slag. 4. Place electrode in holder. 5. Put on gloves and helmet. 6. Place metal together, parallel to each other, leave root gap from 3/32" to 1/8" in flat position. 7. Use a spacer wire to maintain proper root gap, place a 1/4" tack weld in root at one end. 8. Use same spacer at other end, place second tack; remove spacer wire. 9. Place strip of metal under each end of plates to keep metal off table when welding.	Text: Welding Shields and Practices

Parts of a Weld



10. Position electrode straight into weld and angle 5 to 10 degrees away from weld puddle; travel from right to left.
11. Penetrate joint completely.
12. Strike high arc length to heat plate; move to end and weld plates together with stringer bead.
13. Root pass (bottom of vee) should have 100% penetration on both plates, extending through root and overlapping 1/16" on each side.
14. Chip slag and brush weld clean.
15. Deposit necessary passes to fill rest of vee, using care to remove all slag between each pass; use stringer beads or weave passes.
16. Make cover pass or passes convex, overlapping edge of grrove 1/16" each side.
17. Clean by chipping and brushing.

10.17 Common Causes of Welding Problems

A. Undercutting

1. Cause.
   a. faulty electode manipulation.
   b. faulty electrode use.
   c. current too high.
2. Correction.
   a. use uniform weave in butt welding.
   b. avoid overly large rod.
   c. avoid excessive welding.
   d. use moderate current, weld slowly.

ILS Industrial Mechanics 603-1

2. Correction.
   a. change welding technique.
   b. avoid overheating.
   c. avoid high current.

E. Spatter
   1. Cause.
      a. arc blow.
      b. current too high.
      c. arc too long.
   2. Correction.
      a. adjust current.
      b. adjust arc length.
      c. use correct electrode.

F. Porous Welds
   1. Cause.
      a. short arc.
      b. insufficient puddling time.
      c. poor electrode.
      d. impurities in base metal.
   2. Correction.
      a. allow time for gases to escape from puddle.
      b. use proper current.
      c. weave to eliminate pin holes.
      d. hold longer arc.
      e. use proper rod.

G. Distortion
   1. Cause.
      a. uneven heating.
      b. improper sequence.
      c. deposited metal shrinks

2. Correction.
    a. tack or clamp parts properly.
    b. distribute welding to prevent uneven heating.
    c. examine structure and develop sequence for welding.

H. Cracked Welds
    1. Cause.
        a. wrong electrode.
        b. weld and part sizes unbalanced.
        c. faulty preparation.
        d. faulty welds.
    2. Correction.
        a. heat parts before welding.
        b. avoid welds in string beads.
        c. make sound welds of good fusion.
        d. keep ends free to move as long as possible.
        e. adjust weld size to part size.
        f. allow joints a proper and uniform free space.

I. Arc Blow or Magnetic Blow
    1. Cause.
        a. magnetic field causes arc to wander from its intended path.
    2. Correction.
        a. use AC welding.
        b. use short arc.
        c. weld in same direction as arc blows.
        d. locate ground in different place on work.
        e. use steel blocks to alter magnetic path around arc.

J. Warping

1. Cause.
   a. shrinkage of weld metal.
   b. faulty part clamping.
   c. overheating of joint.
2. Correction.
   a. weld rapidly.
   b. avoid excessive space between parts.
   c. clamp parts properly. Back-up to cool.
   d. use high speed, moderate penetration electrodes.

K. Brittle Welds

1. Cause.
   a. wrong electrode.
   b. faulty preheating.
   c. metal hardened by air.
2. Correction.
   a. preheat medium or special alloy steels.
   b. make multiple layer welds.
   c. anneal after welding.

10.18 Bead with Filler Rod in Vertical Position

A. Method

1. Assemble materials and equipment.
   a. oxy-acetylene unit, welding rod, goggles, striker, pliers, gloves, pieces of light-gage steel 1 1/2" X 6".

ILS W2401

2. Place work in upright position, either leaning against firebrick, or clamp in a work-holding device.
3. Start weld at bottom of sheet and weld upward.
4. Hold flame at one point until puddle is formed.
5. Hold welding rod in enveloping flame so it comes to melting point about same time as base metal.
6. Torch angle from 45 to 75 degrees from work in direction of travel (pointing up).
7. Hold rod downward into puddle at about 30^{o} angle.
8. Use same torch motion as for welding bead on flat sheet.
9. Hold flame in puddle, then raise torch so rod is melted as it is deposited into the puddle; allow enough metal to be deposited to form "shelf".
10. Once shelf is established, continue to deposit layers of metal on shelf, thereby forming bead.
11. Make bead to top of sheet.

10.19 Bead with Filler Rod--Horizontal Position

A. A more difficult weld because molten metal has tendency to sag and must be controlled by the welder. ILS W2201

B. Method

1. Assemble material and equipment.
   a. oxy-acetylene welding unit, welding rod, gloves if needed, welding goggles, striker, pliers, two pieces steel 12-gage 1 1/2" x 6".
2. Set regulator pressure.
3. Place piece of metal in holder horizontally (or straight up and down) but longer side at top and bottom.
4. Point tip at 45^{o} lead angle (pointing in direction of travel) and 70^{o} from bottom of plate (pointing somewhat in upward direction); tip position will enable force from velocity of burning gases to keep molten metal in place.
5. Hold rod at 45^{o} to work.
6. When making weld, place rod in upper half of puddle slightly above cone of flame.
7. Beads should be uniform in height and width with no sag at bottom edge.

10.20 Bead with Filler Rod--Overhead Position

A. Method

1. Assemble materials and equipment.
   a. oxy-acetylene unit, welding rod, goggles, pliers, striker, gloves, light-gage metal 1 1/2" X 6", tip.
2. Set regulator pressure and prepare torch.
3. Place metal piece in holder and place in flat position 6" over head.
4. Set sheet to weld length.

ILS W2301

5. Weld toward body or away from body.
6. Point tip in direction of travel, at angle of about 75^{o} from work.
7. Do not use side motion or puddle will become too large and will be difficult to control.

10.21 Weld Open Butt Weld in Vertical Position

A. Method

ILS W2404

1. Assemble materials and equipment.
   a. oxy-acetylene welding unit with tip, filler rod, goggles, striker, pliers, two pieces of light-gage steel 1 1/2" X 6".
2. Place metal pieces side by side on table and space about 1/16" apart one end and 1/8" apart on other.
3. Tack at 2-inch intervals.
4. Place pieces in holding device in upright (vertical) position with narrowest spacing at bottom.
5. Weld from bottom to top, making sure of complete penetration.
6. Use same procedure as when welding beads in same position.
7. Do not use excessive side motion with flame.
8. Weld should be even in width and height, with complete penetration.

10.22 Weld Open Butt Joint in Overhead Position

A. Method

1. Assemble equipment and materials.
   a. oxy-acetylene welding equipment and tip, striker, pliers, goggles, filler rod, two pieces light-gage steel 1 1/2" X 6".
2. Set regulator pressure.
3. Tack pieces side by side with 1/16" space at one end and 1/8" at other end.
4. Place in work-holder and position flat at least 6" overhead.
5. Weld toward body or from right to left starting at narrow end.
6. Use same technique as overhead beads.

ILS W2304

10.23 Weld Open Butt Joint in Horizontal Position

A. Method

1. Assemble equipment and material.
   a. oxy-acetylene welding unit and tip, filler rod, goggles, spark lighter, pliers, two pieces light-gage steel, approximately 1 1/2" X 6".
2. Tack metal side by side with one end 1/16" apart and other 1/8", tack at 2-inch intervals.
3. Place pieces in holding device in horizontal position.
4. Use same technique as for welding horizontal beads.
5. Welds should have complete penetration.

10.24 Weld Fillet Weld in Vertical Position

A. Method

ILS W2402

1. Assemble material and equipment.
   a. oxy-acetylene unit, filler rod, goggles, striker, pliers, pieces of light-gage steel 1 1/2" X 6".
2. Place one piece flat on table, fire-brick covering one side of plate; place second piece on top of piece, forming "T".
3. Tack weld pieces in place.
4. Adjust flame on torch to slightly oxidizing flame.
5. Turn T on end; weld from bottom to top; point tip into corner with angle about 45^{o}, pointed upward.
6. Direct flame evenly over both plates, keeping inner cone of flame about 1/8" from surface of molten puddle.
6. Complete weld on one side of T; to weld second side, use more heat or larger tip.

10.25 Weld a Fillet Weld in Horizontal Position

A. Method

ILS W2102

1. Assemble material and equipment.
   a. oxy-acetylene unit, filler rod, welding goggles, spark lighter, pliers, two pieces light-gage metal 1 1/2" X 6".

2. Place one piece of metal flat on table; place firebrick on metal, covering about one half of one side; place second piece on top of first, on edge and lean against firebrick; vertical piece should be about 90^{o} angle to first; should form a T.
3. Tack weld pieces.
4. Adjust flame for a T weld by adding a little extra oxygen to flame.
5. Hold torch so tip forms an angle of about 45^{o} to flat plate and same angle to line of weld; point rod toward welding tip at angle of about 45^{o} to line of weld and 45^{o} to flat piece.
6. Direct flame evenly over both plates, keeping inner cone of flame about 1/8" from surface of puddle; if vertical piece gets hot before flat piece, flame should be directed more at flat piece.
7. Tendency is to heat vertical plate too much, causing undercutting above weld, a groove above weld.
   a. to prevent undercutting, add welding rod to top side of puddle just above cone of flame; velocity of flame will force metal to top of puddle.
8. Heat area until puddle is formed, insert filler rod into puddle, allowing rod to melt until bead is flat across pieces at about 45^{o} angle; move torch forward about 1/16" and repeat operation.

10.26 Weld a lap Joint in Vertical Position

A. Method

1. Assemble equipment and material.
   a. oxy-acetylene unit and tip, filler rod, goggles, pliers, striker, three pieces light-gage steel 1 1/2" X 6".
2. Set regulator pressures.
3. Place two pieces of metal flat on welding bench or firebrick as though making a butt weld; place another piece on top of other two, halfway on each piece; should leave lap of 3/4".
4. Tack weld at both ends, insure that no gap exists between pieces; only two pieces should be tacked together; third piece is support only; tack at 2-inch intervals.
5. Place pieces in holding device in vertical position.
6. Direct more of flame onto surface of back piece; point tip in exact direction in which weld is to proceed at about 15^{o}; do not allow front piece to melt away; torch should be pointed more toward back piece; welding rod should be deposited in molten puddle near edge of front piece; protects edge of the piece.
7. Welded portion (bead) must be at least as thick as original metal; add enough welding rod to crown weld slightly.

ILS W2405

10.27 Weld Lap Joint Fillet Weld in Horizontal Position

A. Method

ILS W2205

1. Assemble equipment and materials.
   a. oxy-acetylene unit with tip, filler rod, striker, goggles, pliers, three pieces of light-gage steel approximately 1 1/2" X 6".
2. Set regulator pressures.
3. Place two pieces of metal on work table as though making a butt weld; place another piece on top, half on each piece.
4. Tack both ends of top and one bottom piece and also at 2-inch intervals along line of weld; third piece should not be tacked.
5. Place piece in holding device in horizontal position; weld both sides as they appear in first placement.
6. Weld as though making fillet weld; filler rod should be added to puddle next to edge to protect it from being melted away.
7. Weld bead must be as thick as original metal.

10.28 Fillet Weld in Overhead Position

A. Method

ILS W2302

1. Assemble equipment and material.
   a. oxy-acetylene welding unit filler rod, goggles, striker, pliers, two pieces of light-gage steel 1 1/2" X 6".

2. Place one piece of metal on table; place second piece on first in middle to form T; vertical piece should be approximately 90^{o} to flat piece; tack at each end at 2-inch intervals.
3. Place in holding device in overhead position at least 6" above head.
4. Point tip into corner at angle of 20^{o}, about 20^{o} from top piece.
5. Direct rod into puddle at about 90^{o} from torch angle.
6. Deposit rod in upper half of puddle slightly above cone; velocity of burning gases will assist in flowing molten metal onto upper metal piece.

SUGGESTED READING

Giachino, J. W.
Weeds, W.
Welding Skills and Practices

American Technical Society, 1976

11.0 Basic Welding Applications

INSTRUCTIONAL OUTCOMES: Student will demonstrate and execute basic trade skills by completing a project to the satisfaction of the instructor.

INTRODUCTION: This instructional unit provides students an opportunity to practice techniques followed in the Pacific Northwest; appropriate techniques will have been learned in previous topics in this guide.

PRESENTATION

TEACHING OUTLINE	TEACHING METHODS AND AIDS
11.1 Welding a Barbecue Grill A. Prepare Angle Iron 1. Mark to length; 2 pieces 20", 2 pieces 23". 2. Cut to length using cutting tip. 3. Cut lower leg ends a 45^{o} angle. 4. Clean off slag. B. Prepare 1/4" Round Stock. 1. Cut 20 pieces to 19 5/8" length. C. Assembly of Angle Iron Frame 1. Set 4 pieces to form rectangle. 2. Tack weld at opposite corners. 3. Check for squareness. 4. Weld corners.	Explain and Discuss Administer Project Sheet

D. Attachment of Round Rod

1. Mark angle iron frame at 1" intervals on flat inside surfaces of 23" sides.
2. Place steel rod on marks and tack in place.
3. Weld rods in place.
4. Turn grill right side up and check for smoothness and rigidity.

E. Additional Reinforcement (optional)

1. Cut round stock at 22 5/8".
2. Mark placement along 20" side.
3. Rod should run perpendicular to grill surface rods on under side, tack in place.
4. Weld rod in place.

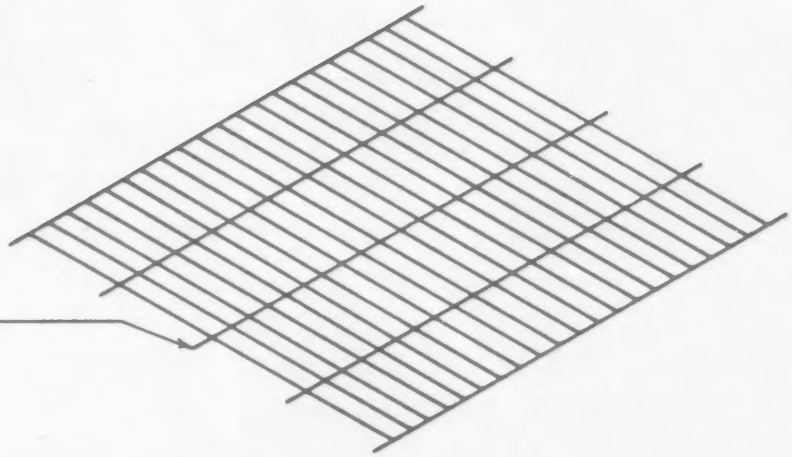
WELDING PROJECT SHEET

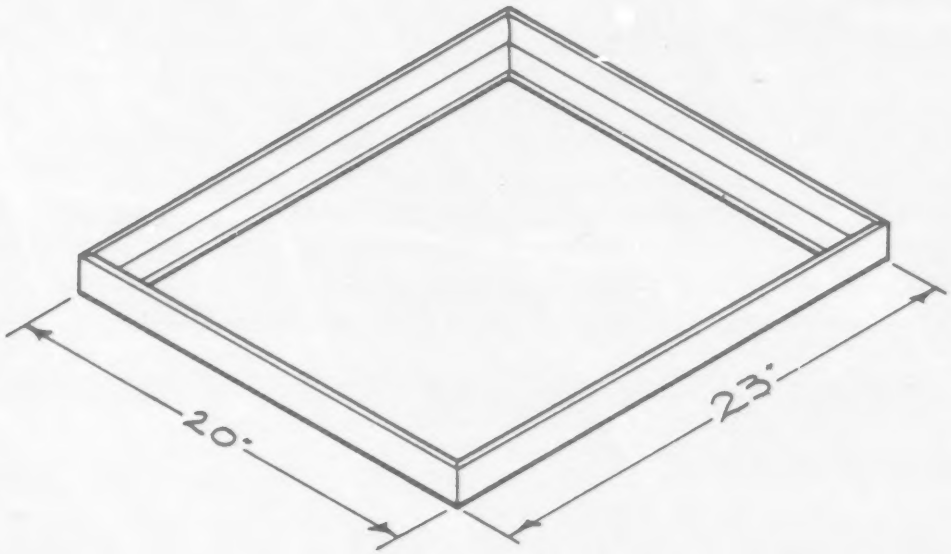
1. Barbecue Grill

The student will fabricate a barbecue grill safely and to industry standards.

EQUIPMENT AND MATERIALS

Oxy-acetylene setup
cutting tip
#1 welding tip
pliers
goggles
soapstone or chalk
gloves
filler rod 1/8"
8' X 1" angle iron
34' or 400" 1/4" smooth round steel or rebar





86"	1" ANGLE IRON	
34'	1/4" ROUND STOCK	
QTY.	DESCRIPTION	PART NUMBER

STEPS TO COMPLETION

1. Mark angle iron for cutting two pieces upper leg at 20" and two pieces upper leg at 23"; lower (flat) leg cut at 45^{0} angle.
2. Cut with cutting tip.
3. Clean off slag.
4. Mark smooth round steel at 19 5/8".
5. Cut 20 pieces.
6. Set pieces of angle iron together to form rectangle, tack weld at each opposite corner; check for squareness.
7. Weld corners.
8. Mark 20 places at 1" intervals on flat inside surface of 23" sides.
9. Place steel rods on marks and tack each in place.
10. Weld rods in place.
11. Turn grill right side up and check for smoothness and rigidity.

APPENDIX

OCCUPATIONAL ANALYSIS

WELDING (9)

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COMBINATION WELDER*

OCCUPATIONAL ANALYSIS

State Department Code #

U.S.O.E. Instructional Group Code: 17.230603

D.O.T. # 812.884.014

PRINCIPAL INVESTIGATORS

State Department Specialist: RALPH LITTLE

Curriculum Staff Assigned: JOHN BARTON

Task Analyst (s): CHARLES R. STEVENS

Date Analysis Completed: 5-27-76

*NOTE: This occupation is a key occupation in Oregon as identified by Oregon Criteria.

TASK INVENTORY REVIEW COMMITTEE

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TASK INVENTORY

Combination Welder
Job Title

Charles R. Stevens
Analyst

INSTRUCTIONS:

List each manipulative and knowledge skill relating to the job noted above. To the right of each task is a series of columns asking specific questions about the entry level, level of difficulty, frequency, and type of skill involved. Place an "X" in each of the four categories opposite the task description.

Duty No.	Task No.	Task Description	Entry Level		Level of Difficulty			Frequency		
			Entry	On The Job	Easy	Moderate	Difficult	Small Amount	Average Amount	Great Amount
1	0	General								
	1	Identify Base Metal	X				X		X	
	2	Select proper welding machine or cutting equipment	X			X			X	
	3	Adjust equipment controls	X			X				X
	4	Read and interpret welding symbols	X			X				X
	5	Connect machine to base metal	X		X					X
	6	Obtain and use correct protective equipment	X		X			X		
	7	Observe all safety requirements		X		X			X	
	8	Use jigs, fixtures and clamps to hold parts		X		X			X	
	9	Read and interpret print dimensions and requirements	X			X			X	
	10	Perform welding or cutting per print and/or supervisor's instructions.	X			X				X
	11	Clean slag from weldment or part	X		X					X
	12	Inspect work and repair when needed		X		X			X	
	13	Troubleshoot simple equipment problems	X			X		X		

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			Entry	On The Job	Easy	Moderate	Difficult	Small Amount	Average Amount	Great Amount
2	0	Manual shielded metal-arc welding								
	1	Identify type of base metal to be welded	X				X		X	
	2	Select type of welding machine (alternating current or direct current)	X			X			X	
	3	Select proper electrode for base metal and welding machine	X				X		X	
	4	Set correct polarity on direct current type welding machines	X			X			X	
	5	Connect welding machine ground cable to base metal	X		X				X	
	6	Read and interpret welding symbols on drawing	X			X			X	
	7	Adjust welding amperage	X			X			X	
	8	Use proper protective equipment for welding	X		X				X	
	9	Observe all safety rules	X			X			X	
	10	Assemble component parts in welding jigs or tack weld parts together per print.		X		X			X	
	11	Deposit welds in weldment joints	X			X				X
	12	Remove weld slag and spatter	X		X				X	
	13	Measure weld size	X		X				X	
	14	Remove weldment from jig		X		X			X	
	15	Grind weld as required by print		X	X			X		
	16	Identify & correct arc interference	X				X		X	

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			Entry	On The Job	Easy	Moderate	Difficult	Small Amount	Average Amount	Great Amount
3	0	Gas metal-arc welding								
	1	Identify base metal	X				X		X	
	2	Select type of power source	X			X		X		
	3	Select wire drive and control		X		X		X		
	4	Select type and size welding gun	X			X		X		
	5	Determine proper electrode	X			X			X	
	6	Select correct shielding gas	X			X		X		
	7	Obtain proper safety equipment	X		X				X	
	8	Load reel or spooled electrode on wire drive	X		X				X	
	9	Inspect wire drive rolls for correct size - change if required.	X		X				X	
	10	Inspect electrode conduit for correct size - change if required.		X		X			X	
	11	Inspect electrode contact tip for correct size - change if required.	X		X				X	
	12	Install correct shielding gas nozzle on welding gun.	X		X				X	
	13	Feed electrode through drive rolls, conduit and contact tip.	X		X				X	
	14	Adjust drive roll pressure	X			X			X	
	15	Secure shielding gas bottle to welding machine or wall.	X		X			X		
	16	Connect flow meter to gas bottle.	X		X			X		
	17	Adjust shielding gas flow rate.	X		X			X		
	18	Inspect welding gun coolant.	X		X			X		
	19	Connect ground cable to weldment.	X		X				X	
	20	Adjust electrode speed (amps).	X				X		X	
	21	Adjust load voltage, slope & inductance controls	X			X			X	
	22	Load component parts in jig.		X		X			X	
	23	Interpret welding print symbols and dimensional requirement.	X			X			X	
	24	Deposit welds.	X			X				X
	25	Clean weld spatter from gas nozzle.	X			X				X
	26	Replace worn contact tube.	X		X				X	
	27	Replace damaged gas nozzle.	X		X			X		
	28	Clean weldment.		X	X				X	
	29	Grind and repair welds.		X		X		X		

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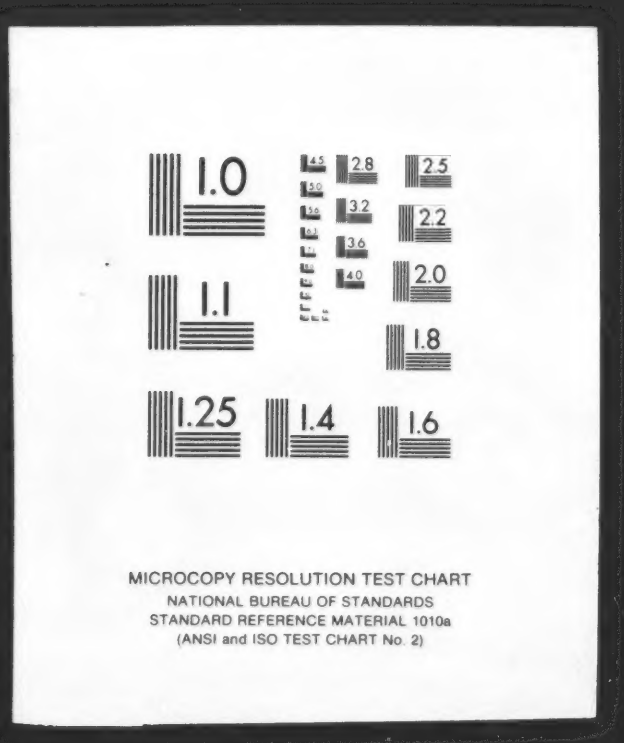
			Entry	On The Job	Easy	Moderate	Difficult	Small Amount	Average Amount	Great Amount
4	0	Gas Tungsten - Arc Welding								
	1	Identify base metal	X				X		X	
	2	Select correct type and size electrode	X				X		X	
	3	Select correct type shielding gas	X			X			X	
	4	Select correct size shielding gas cup	X			X			X	
	5	Install electrode and gas cup on electrode holder	X		X				X	
	6	Adjust position of electrode tip to end of gas cup.	X			X			X	
	7	Secure shielding gas bottle to machine or wall mounting.	X		X			X		
	8	Connect flowmeter to shielding gas bottle.	X		X			X		
	9	Adjust shielding gas flow rate	X		X				X	
	10	Select correct type of welding current on welding machine.	X			X			X	
	11	Determine correct welding machine polarity for base metal.	X			X			X	
	12	Position welding machine polarity switch to correct setting.	X		X				X	
	13	Determine correct amperage setting for base metal thickness and electrode size.	X			X			X	
	14	Adjust welding machine amperage control.	X		X				X	
	15	Adjust shielding gas preflow and post flow timer controls.	X		X			X		
	16	Set high frequency current switch to the correct position.	X		X				X	
	17	Adjust high frequency current intensity control.	X		X				X	
	18	Inspect electrode holder coolant.	X		X				X	
	19	Connect ground cable to weldment.	X		X				X	
	20	Obtain and use correct safety equipment.	X		X				X	
	21	Interpret welding print symbols and dimensional requirements.	X			X			X	
	22	Determine and obtain correct welding rod.	X			X			X	
	23	Form correct electrode tip configuration.	X			X			X	
	24	Load component parts in jig.		X		X			X	
	25	Clean joint with wire brush.	X		X				X	
	26	Position electrode holder to joint.	X			X			X	
	27	Initiate welding arc on joint.	X		X				X	
	28	Adjust remote amperage control for correct weld puddle.	X			X				X
	29	Move electrode along joint and feed welding rod to form proper bead detail.	X				X			X
	30	Extinguish arc at end of weld.	X		X					X

2

A.S


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3
7.1
8.0
9.0
10.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

TASK INVENTORY

Combination Welder
Job Title

Analyst

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Duty No.	Task No.	Task Description	Entry Level		Level of Difficulty			Frequency		
			Entry	On The Job	Easy	Moderate	Difficult	Small Amount	Average Amount	Great Amount
4	31	Protect molten weld crater with post flow shielding gas.	X		X				X	
	32	Clean welded joint.	X		X				X	
	33	Remove weldment from jig.		X		X			X	
	34	Inspect deposited welds.		X		X			X	
	35	Repair welds as required.		X		X		X		

TASK INVENTORY

Combination Welder
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Duty No.	Task No.	Task Description	Entry Level		Level of Difficulty			Frequency		
			Entry	On The Job	Easy	Moderate	Difficult	Small Amount	Average Amount	Great Amount
5	0	Oxy-Fuel Gas Welding								
	1	Identify base metal.	X				X		X	
	2	Select correct filler metal.	X			X			X	
	3	Secure oxygen bottle in cart or to wall bracket.	X		X			X		
	4	Secure fuel gas tank in cart or to wall bracket.	X		X			X		
	5	Observe all safety rules for handling bottled compressed gasses.	X			X			X	
	6	Attach oxygen regulator to oxygen supply	X		X			X		
	7	Attach fuel gas regulator to fuel gas supply	X		X			X		
	8	Attach oxygen and fuel gas hoses to regulators.	X		X			X		
	9	Select correct welding torch body.	X			X		X		
	10	Connect oxygen and fuel gas hoses to welding torch body.	X		X			X		
	11	Select correct welding tip.	X			X				X
	12	Attach welding tip to torch body.	X		X					X
	13	Use correct sequence to turn on gas supply to welding torch.	X			X				X
	14	Inspect all fittings for leaks.	X		X				X	
	15	Obtain correct protective and safety equipment.	X		X				X	
	16	Interpret welding symbols and weldment print requirements.	X			X			X	
	17	Clean joint surfaces.	X		X					X
	18	Load parts in welding jig.		X		X			X	
	19	Adjust regulators for correct pressures.	X			X			X	
	20	Use correct procedure to ignite welding flame.	X		X					X
	21	Adjust welding flame for base metal and welding process.	X		X					X
	22	Use correct torch manipulation to form welded joint.	X			X				X
	23	Add filler metal to form correct weld bead contour.	X			X				X
	24	Deposit welds.	X			X				X
	25	Use correct sequence to turn off welding flame.	X		X					X
	26	Clean welds.		X	X					X
	27	Inspect welds.	X			X			X	
	28	Repair welds as needed.		X		X		X		
	29	Remove weldment from jig.		X	X				X	
	30	Use correct sequence to shut down the welding equipment.	X		X					X

TASK INVENTORY

Combination Welder
Job Title

Charles R. Stevens
Analyst

INSTRUCTIONS:

List each manipulative and knowledge skill relating to the job noted above. To the right of each task is a series of columns asking specific questions about the entry level, level of difficulty, frequency, and type of skill involved. Place an "X" in each of the four categories opposite the task description.

Duty No.	Task No.	Task Description	Entry Level		Level of Difficulty			Frequency		
			Entry	On The Job	Easy	Moderate	Difficult	Small Amount	Average Amount	Great Amount
6	0	Manual Oxygen Cutting								
	1	Identify metal to be cut.	X			X			X	
	2	Secure gas bottles to cart or wall bracket.	X		X			X		
	3	Observe all safety rules for handling compressed gas cylinders	X			X			X	
	4	Attach regulators to fuel gas and oxygen cylinders	X		X			X		
	5	Select correct cutting torch body.	X			X		X		
	6	Connect gas hoses to regulators and torch body.	X		X			X		
	7	Select correct cutting tip.	X			X			X	
	8	Inspect and clean cutting tip.	X		X					X
	9	Attach cutting tip to torch body.	X		X				X	
	10	Use correct procedure to turn on gas supply to cutting torch.	X		X					X
	11	Inspect all connections for gas leaks.	X		X				X	
	12	Obtain and use correct safety and protective equipment.	X		X				X	
	13	Interpret and follow cutting procedure instructions.	X			X			X	
	14	Adjust regulators for correct pressures.	X			X			X	
	15	Use correct procedure to ignite torch preheat flame.	X			X				X
	16	Open cutting oxygen valve and readjust preheat flame if needed.	X			X				X
	17	Position torch to edge of plate to be cut.	X		X					X
	18	Preheat edge of plate.	X		X					X
	19	Open cutting oxygen valve and start cut.	X			X				X
	20	Traverse torch along line on plate for cutting.	X				X			X
	21	Complete cut and close cutting oxygen valve.	X		X					X
	22	Use correct procedure to turn off preheat flame.	X		X					X
	23	Use correct procedure to shut down equipment.	X		X					X
	24	Remove slag from severed plate edges.	X		X					X

TASK INVENTORY

Combination Welder
Job Title

Charles R. Stevens
Analyst

INSTRUCTIONS:

List each manipulative and knowledge skill relating to the job noted above. To the right of each task is a series of columns asking specific questions about the entry level, level of difficulty, frequency, and type of skill involved. Place an "X" in each of the four categories opposite the task description.

Duty No.	Task No.	Task Description	Entry Level		Level of Difficulty			Frequency		
			Entry	On The Job	Easy	Moderate	Difficult	Small Amount	Average Amount	Great Amount
7	0	Air carbon - arc cutting								
	1	Identify base metal	X			X			X	
	2	Select correct power source	X			X			X	
	3	Select correct type & size electrode	X			X			X	
	4	Select correct polarity when using D.C. type power source	X		X				X	
	5	Obtain proper safety & protective equipment	X		X				X	
	6	Connect ground cable to base metal	X		X				X	
	7	Connect compressed air source to carbon arc electrode holder	X		X				X	
	8	Connect carbon arc torch to power source	X		X				X	
	9	Interpret cutting procedure instructions		X		X			X	
	10	Insert electrode in electrode holder	X		X					X
	11	Adjust power source amperage control for correct setting	X			X			X	
	12	Open electrode holder compressed air valve	X		X					X
	13	Contact electrode tip to base metal to initiate cutting arc	X			X				X
	14	Complete cut	X			X				X
	15	Close compressed air valve	X		X					X
	16	Remove slag from severed or groove edges	X		X					X